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TABLE OF CONTENTS.

	Page
LEADING ARTICLES:	
Projected Steel Arch Bridge Over the East River at Hell Gate, New York City (illustrated)	583
Methods Used in Surveys of Coal Mines (illustrated); L. D. Tracy	583
The Responsibility of the Engineering Profession for the Conduct of Public Contracts; C. E. Gillette	587
Large Electrically Operated Gates for the Roosevelt Dam, U. S. Reclamation Service (illustrated); F. W. Hanna	589
Tar Macadam Pavement in Duluth, Minn.; E. K. Coe	592
A Railway Motor Tricycle, South Australian Railways (illustrated)	593
Testing with a Scraper for Obstructions in a Long Water Main	593
Cost of Construction and Operating Expenses of the Municipal Electric Lighting Plant at Burlington, Vt.	594
The Gyroscope Mono-Rail Railway (illustrated)	598
Experiments on Proportioning Concrete to Secure Maximum Strength and Density (illustrated)	599
The American Foundrymen's Association Convention at Philadelphia	602
Eleventh Annual Meeting of the National Fire Protection Association	603
Notes from Engineering Schools	604
EDITORIAL	595
"Where Combination Is Possible, Competition Is Impossible"—The Attitude of Fire Underwriters Toward Municipal Ownership—A System of Numbering for the Atlas Sheets of the U. S. Geological Survey—Uniform Engineering Requirements.	
Honesty in Public Contract Work	595
LETTERS TO THE EDITOR	596
Form for Pile-Driving Records Used on the Norfolk & Southern Ry. (illustrated) T. W. Cothran—A Standard for Street Piping Proposed; Rutger B. Green—Water Pipe Sizes in Various American Cities; W. B. Franklin—Should a Civil Engineer Furnish His Own Instruments? P. A. Ragon—A Test of the Comparative Efficiency of Large and Small Well-Drilled Holes for Heavy Blasting; W. T. Kershner—Lining Track with Jacks; The George H. Gibson Co.; C. H. Delano—Building Department Regulations and Theoretical Ideas on Reinforced Concrete Design; C. A. P. Turner.	
ENGINEERING NEWS OF THE WEEK	604
PERSONALS	605
ENGINEERING SOCIETIES	606

PROJECTED STEEL ARCH BRIDGE OVER THE EAST RIVER AT HELL GATE, NEW YORK CITY.

The largest arch bridge in the world is projected by the Pennsylvania R. R. for a connection between its extension into New York City and Long Island, and the New York, New Haven & Hartford Ry. A steel arch 1,000 ft. in span is to cross the main channel of the East River at Hell Gate, New York City, from the mainland of Long Island to Ward's Island. The adjoining view, reproduced from a lithographed perspective drawing, shows Ward's Island at the left, the Long Island shore on the right, and in the background Port Morris (Borough of the Bronx, New York City) and the continuation of the East River northeastward.

This arch is part of a steel viaduct more than three miles long, extending from the Long Island end of the Pennsylvania R. R. and Long Island R. R. connection, to the Bronx, and passing over Hell Gate, Ward's Island, Little Hell Gate, Randall's Island, and Bronx Kills. The viaduct is to carry four tracks on a stone-ballasted solid floor. Two of the tracks are intended for passenger traffic, and these, by way of the four tunnels of the Pennsylvania R. R. under the East River, pass to the great terminal station now being built in New York City. This will give an all-rail connection through New York City from southern and western points to New England, by way of the Pennsylvania lines through the new tunnels under the Hudson River at 32d St. to the terminal station, thence under the East River to Long Island and by way of the projected viaduct to the New York, New Haven & Hartford R. R. The two freight tracks will use the Long Island R. R. tracks to Bay Ridge, South Brooklyn, at which point cars will be transferred by ferry to the new Greenville piers and yards of the Pennsylvania R. R. on the New Jersey shore. Heretofore both passenger and freight cars have had to transfer from the New Jersey shore to the Port Morris yards by car-ferry, a trip of about a dozen miles.

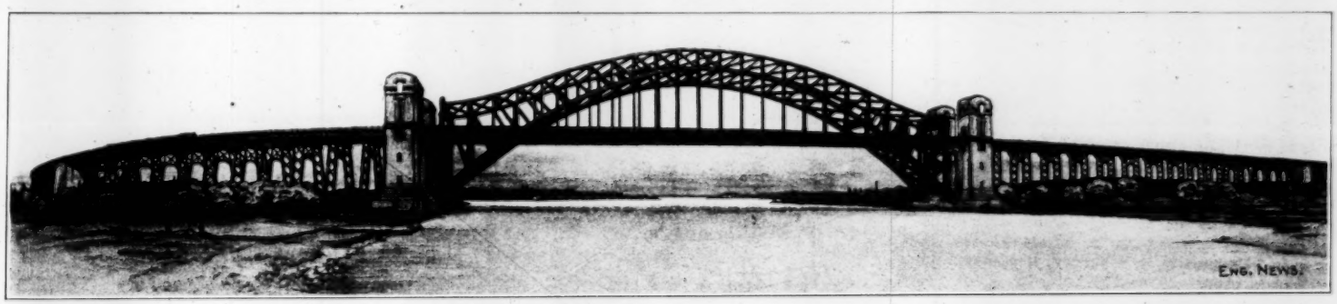
While the magnitude of the entire viaduct, and the character of the railroad connection which it completes, are matters of much interest, yet from an engineering standpoint the great arch over Hell Gate is without doubt the commanding feature. This crossing will be 140 ft. high from mean tide to rail level, while the total height to the top chord of the arch at the crown will be 290 ft. The span of 1,000 ft. compares with that of existing metal arch bridges over 500 ft. in span as follows:

TABLE OF METALLIC ARCH BRIDGES WHOSE SPAN EXCEEDS 500 FT.

	Ft.
Hell Gate, New York City, Railway	1,000
Niagara (Upper Arch), Highway	840
Viaur, France (Three-hinged), Railway	721
Bonn, Germany, Highway	614
Dusseldorf, Germany, Highway	595
Ludwig I.	564
Mungsten or Wupper, Germany, Railway	558
Niagara (Lower Arch), Ry. & Highway	550
Garabit, France, Railway	541
Bellows Falls, Vt., Highway	540
Pia Maria (Portugal?), Railway	525
Eads Bridge, St. Louis, Ry. & Highway	520
Grunenthal, Ry. & Highway	514
Washington Bridge, New York City, Highway	509
Zambesi, South Africa	500

A special effort was made to design a bridge of good appearance, indeed a beautiful structure. For this purpose the engineer who designed it, Mr. Gustav Lindenthal, associated with himself as Consulting Architect, Mr. Henry Hornbostel, of the architectural firm of Palmer & Hornbostel, New York City. The chief architectural addition to the structure is a pair of immense pylons or towers at either end of the arch. These are of granite in the lower portion with concrete above, and rise to a height of 200 ft.

On May 23, 1907, the plans for this bridge were submitted by Mr. Samuel Rea, Vice-President of the New York Connecting R. R., to the Art Commission of the City of New York for approval, in accordance with the terms of the franchise of the railroad company. About three years will be required to build the viaduct and arch bridge. The amount of metal in the viaduct is about 80,000 tons.



THE NEW YORK CONNECTING R. R. BRIDGE OVER THE EAST RIVER AT HELL GATE, NEW YORK CITY.

Designed by Gustav Lindenthal, M. Am. Soc. C. E.; Palmer & Hornbostel, Consulting Architects.

Clear span, 1,000 ft. Height of Roadway, 140 ft. Height of Towers, 290 ft. Height of arch, 300 ft. Total length of bridge and viaduct approaches, 3 miles. Four Railroad tracks. Total weight of steel, 80,000 tons.

METHODS USED IN SURVEYS OF COAL MINES.

By L. D. TRACY,* Assoc. M. Am. Soc. C. E.

In order to understand thoroughly the methods used by engineers in developing a coal field, one should have some knowledge of the physical characteristics of this mineral.

Coal varies in hardness from the very soft bituminous to the very hard anthracite. It is with surveys of bituminous mines that the present paper deals, and the methods described, while applicable generally to most soft coal regions, are especially practiced in the mines in and about Pittsburg and Connellsville, where the finest coking and steaming coal in this country is to be found.

The Pittsburg vein, as it is called, varies in thickness from 2 ft. to about 8 ft., and has a general slope in a southerly direction. Notwithstanding this general slope there are many local rises and falls of the vein. Imagine a piece of corrugated iron held in an oblique position and you will have some idea of the general contour, with this exception—the folds are not always absolutely parallel.

This plane cuts the surface near Pittsburg and its intersection with it causes a line somewhat similar in shape to a contour line. Where the hills are high, the outcrop line, as it is called, can be seen around the sides and along ravines.

One characteristic which plays an important part in mining operations is the cleavage. The bituminous coal of the Pittsburg region has a distinct grain, and can be split in one direction very similar to wood, while it is much more difficult to break it at right angles.

When the coal is cut with the grain it presents a long, very smooth surface known as the "Slip." An entry driven against the grain is called a "Butt" entry, and one with the grain is known as a "Face" entry. An entry driven at an angle of 45° to the face is generally called a "Quartering" entry.

The system of mining used principally in the

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Pittsburg district is generally known as the pillar and entry system, and consists of driving a butt entry and every thirty or forty feet or so, turning a room with the neck about 9 ft. wide for about 21 ft. and then widening to about 24 ft.

Fig. 1 shows the simplest form of entries and rooms. The rooms are driven until they meet the rooms driven towards them. This leaves a pillar of coal 15 ft. in thickness to support the roof. As soon as the rooms are finished, a cut is made across the rib and the coal is taken out and the rib gradually brought back towards the entry.

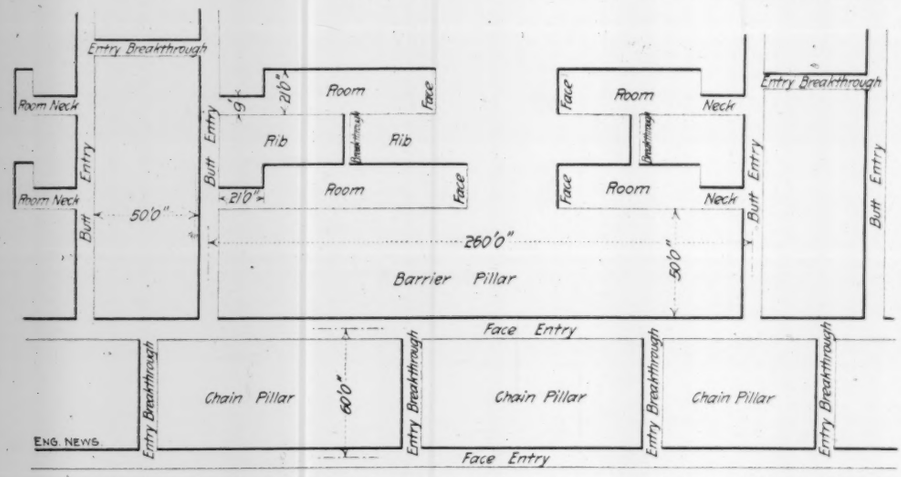

FIG. 1. ILLUSTRATION OF BITUMINOUS COAL MINE SURVEY, SHOWING ENTRIES, ROOMS, ETC.

The rib is left standing for a distance of about 50 ft. or so from the entry and is called a stump. This serves to keep the roof up over the entry so that the rooms farther up the entry may be worked. With this slight description of the operation, a better understanding of the surveying method may be had.

In planning for the future development of a mine, a careful survey should be made of the property, locating the extreme boundary lines, and as many topographical features as possible, such as houses, roads, etc. This survey should be referred to some one meridian, either the true or the magnetic. Each has its advantages.

If the field be large with the possibility of several mines being opened up with the intention of connecting them at some future time, then the true meridian, either obtained from the U. S. Geological Survey or by an observation upon Polaris is desirable.

On the other hand, as the descriptions of the property lines in the original patents and deeds are generally referred to a needle course, it serves to help greatly in a survey, if a magnetic meridian is used.

The principal advantage of the magnetic meridian, however, lies in the use of the compass as a check against errors while working underground.

When an error is made in reading an angle when one is laying out work on the surface, one can often tell by the general appearance that a mistake has been made. For some unexplained reason it does not look right and the mistake can be caught before much harm is done. Furthermore, in reading a vernier an error of degrees is much more likely to occur than an error in minutes, and such an error can be readily detected by the needle. But underground all is entirely different. Working in a narrow space perhaps only 12 ft. wide, in a very dim light at best, there is absolutely nothing to show if a mistake has been made. Hence in turning angles to run a line on a given course, if the calculated and magnetic courses correspond, it enables one to check an error very quickly. Therefore, if there are not a large number of mines in the same field, perhaps the magnetic bearing is preferable.

Coal lands are often bounded on one side by what is known as a "crop line." That is, by the line of intersection of the earth's surface and the general plane formed by the vein of coal. Fig. 2 illustrates a crop line.

The coal near the surface becomes weathered, dirty and unfit for market. In many cases, if the coal land were bought to the crop lines, it would mean several acres of unmerchantable coal. Paid for at the rate of $500 per acre, which is an average price for good coal lands, this would mean several thousands of dollars invested from which there could be no return. It is therefore customary to make coal land purchases to a line formed by the intersection of a plane parallel to and with the ground surface and 15 to 20 ft. above the plane of the coal. Then before a transaction can be completed a crop line has to be staked out and the area between the property lines and the out crop line calculated.

In order to do this, it is necessary to obtain as accurate a knowledge of the general inclination of the vein as possible. Where the surface has washed away leaving the coal exposed, levels may be run between the "blossoms" as they are called, or if there are old workings in the vicinity, the elevations may be obtained. At the same time that the levels are being run, a record

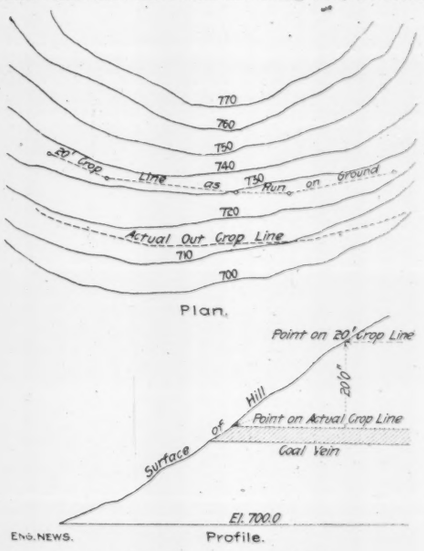

Fig. 2. A Coal "Crop Line."

of the course of the line should be kept. From the data thus gathered, a crop line table can be constructed giving the angle of inclination for each degree of course. The field work is then somewhat similar to stadia work.

Suppose a 20 ft. crop line is to be run. Having a crop line table, a place where the vein is exposed to the surface is found, and a point 20 ft. higher in elevation is found, generally by a Locke level. This point should be tied in with a line the bearing of which is known, in order to determine the course of the crop line. The transit is then set up over the point and the height of the instrument above ground read on the level rod in a similar manner as in stadia work. A point is then chosen about on the same elevation and the horizontal angle read; the bearing is calculated, and from the table the corresponding angle of elevation or depression is taken. The vernier on the vertical circle is set at the angle thus found and the level rod moved a little up or down the hill till the middle cross hair coincides with the rod reading corresponding to the height of the instrument.

Should the horizontal angle be changed to a very great degree, a new course must be calculated, the corresponding vertical angle taken from the table and the level rod again placed. After the correct point has been found, a pin should be driven in the ground—the distance measured and recorded in the notes. Then up the transit is moved and set up over this point and the work proceeds as before.

The area of the field is calculated as in ordinary land surveying, the courses and distances of the crop line being used just as if they were simply division lines between tracts of land.

INSIDE SURVEYS.

Many works on mine surveying prescribe an elaborate outfit for making an inside survey, double telescope transits, tripods for plummet lamps, etc. In reality nothing more is necessary than an ordinary transit having rather coarse cross hairs, a vernier and plates distinctly graduated, and an extension tripod. Beside the transit, a steel tape, plumb bobs, a brace fitted with a ⅜-in. or ½-in. steel drill, a hatchet, some wooden plugs about 6 ins. long, some iron spuds, and a quantity of white lead mixed in linseed oil, is all that is required.

To use a double telescope for sighting down a shaft, a very strong and rigid platform would be required. This would mean a delay in the operation of the shaft which would hardly be allowed, and as all shafts are extremely wet, it would be almost impossible to sight from the bottom to the top.

In regard to the other apparatus, in a busy mine where trips of coal are constantly being hauled along the entry and all work has to be done between trips, too much time would be consumed in setting up a large instrument, to say nothing of the extra exertion involved in transporting it around. In an entry barely 3 ft. 6 ins. high, the less an engineering corps has to burden itself with the better, especially when just as great a degree of accuracy can be obtained as in surface field work.

The first important step in both inside and outside work is to establish a well-monumented base line as long as possible and convenient to the entrance to the mine, and to which all inside and outside surveys are tied. The meridian of this line should be established. If the entrance to the mine is by a drift or slope opening, this is comparatively a simple matter, a drift simply being an entry driven into the side of a hill at the outcrop line and following the vein of coal. A slope is just what its name indicates, a sloping way from the surface down to the coal vein, some 75 ft. or so below the surface. When, however, the coal seam is more than 100 ft. deep, and is reached only by a shaft, the task becomes more difficult.

Sometimes it happens that two shafts have been sunk simultaneously some two or three hundred feet apart and have been connected by an entry. If this is the case, a point at the top of each shaft may be located by triangulation and the course of the line connecting them calculated. From these two points heavy weights may be suspended in the shaft and immersed in oil or water at the bottom. A transit may be set up midway between these points and gradually worked into exact line, thus giving a course identical with the one above.

If, however, there is only one shaft, two points should be taken, one on each side of the shaft. Generally there is a compartment in the shaft for pipes, electric wires, etc., which will be com-

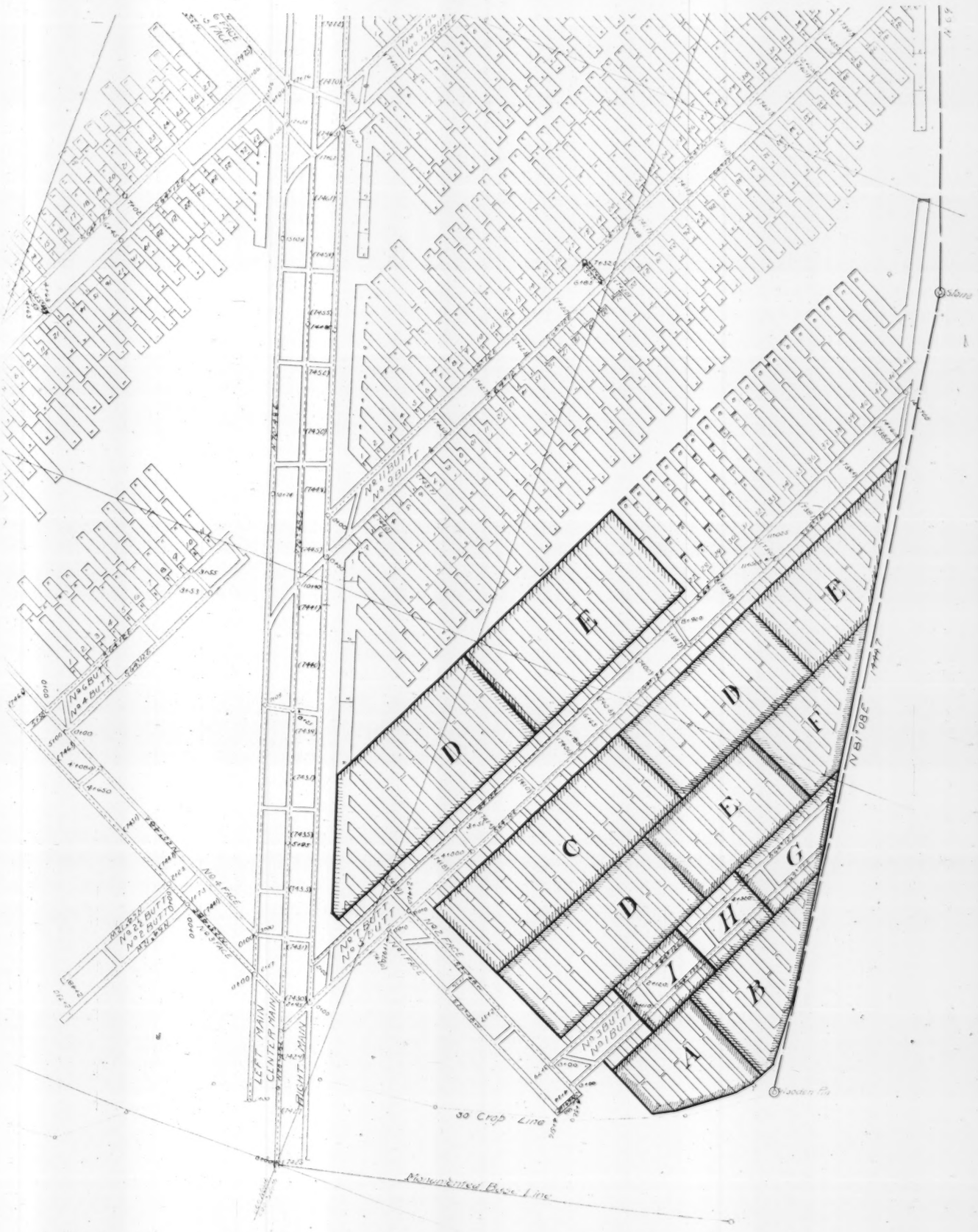

FIG. 5. PART OF A COAL MINE MAP SHOWING METHODS OF WORKING AND SURVEYING.
(In the original, the survey lines are in red.)

paratively free from the vibrations caused by the hoisting cages. Locate these two points from the surface, and suspend weights from them by wires.

There are many ways of locating these wires at the bottom, but the following is very simple, and if care is taken, accurate. After the wires are absolutely still, they should be tested to see that they are hanging clear and not in contact with anything. If it is impossible to follow the wires up the shaft by a cage, a good way is to drop some light washers of iron or leather through the center of which the wire has previously been passed. If any object is in contact with the wire, these will not fall to the bottom. But if they come down as soon as dropped, it is safe to assume that the wire hangs clear. Then take two lengths of fine wire and fasten them

at right angles, or as nearly so as possible to each other, their intersection being exactly at the suspended wire; remove the weights and set the transit up immediately under the intersection. Sight upon the wire at the other side of the shaft and prolong the line down the entry if possible. Should the entry not be in line, then place a point in the entry, and carefully measure the angle. Check this operation several times and take the mean of the result. Care should be taken to place the points in the base line thus obtained in such a position that they will not be disturbed by future improvements or alterations in the mine. Also in a good sound roof which will not fall down.

The entries are kept on their course by means of two wooden plugs in which are driven iron spuds lined in by a transit. Sights are generally placed about 3 ft. apart. Strings are hung from these spuds and the mine foreman lines in a light held at the extreme end of the entry with the line formed by these strings and a mark is made on the roof to guide the machine cutters.

Stations should be plainly marked with white lead and the same system of marking should be carried through the mine. Much confusion is avoided and liability of error lessened if points at which the course is carried forward are differently designated from the stations at which an angle is turned. For instance, all straight line points may be marked with a circle around the point and on the rib, and all points at which an angle is turned similarly marked with a triangle.

If the survey is for the purpose of keeping track of the progress of a continuously working mine, it is well to denote the survey stations as in railroad work, the zero being at the station on the main entry from which the entry in question is turned off. This is useful to the mine foreman in being able to recognize at a glance the distance the entry has been driven. If the survey is of an old working the system of giving each station a reference number is much used. Every means should be taken to keep the notes clear, and if numbers are used to designate the stations, a sketch showing the general character of the survey is very useful.

Leveling is as much a part of the survey as the transit work, and in entries where the grade is not more than 2%, elevations should be taken every 100 ft. If the grade is irregular or very steep, every 50 ft. or as often as necessary to show an accurate profile. The zero points of the level stations should correspond, if possible, with the zero point of the transit lines.

After the completion of the surveys, naturally the next step is the preparation of a working plan of the mine. An accurate and reliable map is really the foundation of the economical mining of a coal property, for from this plan alone can the most advantageous grades for hauling the coal be determined and the amount of coal lost in the mining be learned as well as the drainage and ventilation systems be planned. Consequently all precautions should be taken to have it represent, as nearly as possible, the conditions as they actually exist. Every check practicable should be used to verify the surveys. As many circuits as possible should be made through the entries and the error of closure determined. This can be easily done where the so-called panel system of mining is used. By this system, the mine is divided into large rectangles by pairs of face entries, driven parallel to each other about 1,000 ft. apart, intersected at right angles by the pairs of butt entries every 250 to 300 ft. The circuits of the survey are made by lines running through the entries bounding the square. As can be readily seen, the mine is divided somewhat like a huge checker board, and many combinations of circuits, each checking the other, may be made. In addition, when a pair of entries are being driven to a distance of say 2,000 to 3,000 ft., it has been the custom of the writer to require a tie to be made through a "break through" every 500 ft. or so, to the surveylines in the entries. In this manner any error in measurements or in reading angles can be detected by calculating the circuit made.

The map should always be plotted by the coordinate system and a record of the final or total coordinates systematically kept. Then by a comparison of these coordinates, figured by the different ties, the accuracy of the work can be seen at a glance.

From the stations of the survey lines on each entry, the location of the center of each room is determined and the length measured from time to time, as it is driven up. Generally these measurements are made every three months. It often happens that a room is driven to its length and the roof falls in between these quarterly surveys. To obtain accurate data for these rooms, a book is provided for the mine foreman at each mine and as soon as a room is finished he is required to measure it and record its length. When the engineering corps make their regular rounds, these measurements are taken from the record book and entered in their own field book with a notation that they are mine foreman's measurements. This often proves advantageous should at any time the plan be required to be proven in court.

Entry Number —

Room Number	Station	Direction widened	Width	Length of Room from center of Entry A	B	C	D	E	Remarks
25	8+00	Right	24'	55'	106	150 Room #0	Rib at 75	Stump	Room Finished
26	8+39	"	24'	50'	100	146 Room #7	Rib at 60	"	"
27	8+78	"	23'	45	138	150	Rib at 120	Rib 80	Room Finished
Entry Break Thro	8+90	"	10						
28	9+16	"	25		10	75	125	150	Room Finished
29	9+45	"	26		10	80	90	90	Room Stopped for Poor Roof
Entry Break Thro	9+60		10						
Face of Entry			10	9+85		10+00	13+10	14+00	
									Entry Finished

FIG. 4. FORM FOR RECORDING QUARTERLY MEASUREMENTS.

Besides the actual underground workings of the mine, there should be placed on the map all information both as to the surface and beneath, which in any way may be of use to the officials in direct charge of the mining operations. Naturally of the surface information the extreme boundary or property lines are most important, and included under this head are all landmarks, which in case of dispute, will help to trace the original "patent" or "grant" lines, such as corner stones, witness trees and line trees. In case the entire field is made up of a collection of smaller properties or farms, it is convenient to have these subdividing lines shown, because it enables the mine officials to more easily locate on the surface the workings underneath. For the same reason, county roads, important buildings and streams should be shown.

When the surface over the coal is growing shallow, and especially under small streams of water, it is of great advantage to the mine superintendent to have 5 ft. contours of the surface shown, so that he may at any time ascertain the amount of covering over the coal. Then, wherever necessary, blocks of coal may be left in to prevent the roof from caving and causing surface cracks and allowing the water to enter.

The dates at which the measurements of the room were made are indicated by the letters placed at the face of the room or entry. After the room has been driven its required length, the ribs are drawn. The progress is indicated by a line drawn across the rib and its proper letter written under it. This method is illustrated in the accompanying plan, on No. 7 Butt Entry, beginning at Room No. 27. The heavy dark lines represent portions where all the coal has been mined, the large letters denoting the date at which the survey showed the conditions indicated.

The inside levels should be shown in some distinctive way, so that they may not be confused with the survey stations. Enclosing the elevations in parentheses is a very good way.

One of the most important things for a good mine map is to have a good nomenclature for the different entries and to have it appear upon the map. This is most invariably done in large companies, but the writer has often run across mine maps, especially in West Virginia, where the laws are less strict than in Pennsylvania, without a course, distance, room number or even an entry number plotted on. Unless one was absolutely familiar with the mine, it was a confusing task to understand the map. A letter from the mine superintendent referring to such and such an entry often caused much trouble, as it could not be located on the mine map. The miners have a habit of calling the different entries by local names, such as "The Klondike," "The Hill," etc., which are totally different from those intended. The mine officials sometimes fall into the same habit. Much of this trouble may be avoided by adopting a good system of numbering the entries and then painting its number at the beginning of each entry.

However, care must be taken not to crowd too much on the plan and obscure its real object, namely, that of presenting a clear and accurate representation of the actual conditions as they exist in the mine.

As has been mentioned, a systematic record of surveys and other information should be kept, and especially of those calculations which are used in plotting. The coordinates of each survey point should be recorded, each entry by itself. Sheets ruled as shown in Fig. 3 and bound in book form have proven very satisfactory.

In order to readily appeal to the eye, connecting ties are recorded in the book in red ink, showing at a glance the accuracy of the work, at the same time preventing confusion when carrying along the totals for the following stations.

Every deed conveying a piece of property should have a plot and tabulation from deed description, and one from actual survey filed away convenient of access. If possible a plot showing the different descriptions in the title abstract should accompany this.

In regard to the notes, it is a difficult task to

COORDINATES OF NO. 3 FACE.

Station.	Course.	Dist.	North.	South.	East.	West.	Total, North.	Total, South.	Total, East.	Total, West.
0+00 Left Main.....	.....	.....	.....	.....	.....	.....	159.90	.....	307.80	.....
0+00— 1+73.0.....	N25°48'E	173.0	155.75	.....	75.30	.....	315.65	.....	383.11	.....
1+73— 2+23.0.....	"	50.0	45.02	.....	21.76	.....	360.67	.....	404.87	.....
2+23— 4+65.0.....	"	242.0	217.87	.....	105.33	.....	578.54	.....	510.20	.....
4+65—11+28.0.....	"	663.0	596.90	.....	288.56	.....	1,175.44	.....	798.74	.....
11+28—15+98.0.....	"	470.0	423.15	.....	204.56	.....	1,598.59	.....	1,003.30	.....
15+98—17+04.0	"	106.0	95.43	.....	46.13	.....	1,694.02	.....	1,049.43	.....
No. 3 Face No. 4 Face 17+04 16+53	S64°12'E	50.0	.....	21.76	45.02	.....	1,672.26	.....	1,094.45	.....

COORDINATES OF NO. 4 FACE.

Station.	Course.	Dist.	North.	South.	East.	West.	Total, North.	Total, South.	Total, East.	Total, West.
0+00 = 3+00 L Main	.....	.....	.....	.....	.....	.....	183.90	.....	376.73	.....
0+00 — 5+00.0.....	N25°48'E	500.0	450.16	.....	217.62	.....	634.06	.....	594.35	.....
5+00 — 5+50.0.....	"	50.0	45.02	.....	21.76	.....	679.08	.....	616.11	.....
5+50 —10+50.0.....	"	500.0	450.16	.....	217.62	.....	1,129.24	.....	833.73	.....
10+500—11+00.0.....	"	50.0	45.02	.....	21.76	.....	1,174.26	.....	855.49	.....
11+00 —16+03.0.....	"	503.0	452.86	.....	218.93	.....	1,627.12	.....	1,074.42	.....
16+03 —16+53.0.....	"	50.0	45.02	.....	21.76	.....	1,672.14	.....	1,096.18	.....

FIG. 3. SAMPLE RULING FOR RECORD BOOKS OF MINE SURVEYS.

prescribe any one form, as each and every engineer has his own favorite methods. But a book showing a sketch of the entry surveys and another for quarterly measurements have been found of great use. The latter of these was ruled as shown in Fig. 4.

The letters indicate the date at which the measurements were made and should be indexed in the front of the book. Dates of surveys are of the utmost importance, often those which are several years old being referred to in lawsuits and other matters.

The methods explained in the foregoing are not necessarily the only ones used in underground surveying, nor can they claim to be the best devised, but they have been found to be very satisfactory and from them any engineer can work out a system best suited to his need.

THE RESPONSIBILITY OF THE ENGINEERING PROFESSION FOR THE CONDUCT OF PUBLIC CONTRACTS.

By MAJOR CASSIUS E. GILLETTE.*

As the medical profession suffers from quacks and frauds, so the engineering profession suffers from those of its members who aid and abet in or wink at the execution of fraudulent contracts.

The medical profession takes measures as an organization to protect its reputation from the injury done by quacks and frauds; but the engineering profession generally leaves such things for "local treatment." The writer believes that there is a smaller percentage of disreputable men among engineers than in any other profession; and for that very reason he would urge united action to improve even that good record.

The object of this paper is to suggest a few points bearing upon the engineer's responsibility with reference to public contracts; a subject that goes to the very vitals of our national existence. A famous Admiral, after his defeat in action, was asked as to the whereabouts of certain heavy ammunition which he should have had at the battle but did not have. He replied that he supposed it was "in the pocket of the Chief of Ordnance." When graft gets our Army and Navy in its clutches, our history as a nation will have been written. But after the graft canker has thoroughly permeated our municipalities and our states it will surely spread to our National government and our military forces—and then somebody will have our ammunition "in his pocket" at the critical time. It is therefore a matter of serious importance to kill this "dry rot" where it begins.

One would naturally imagine that municipal affairs carried on by officials who are spending the money of their friends and neighbors would be less permeated with graft than state affairs and that state affairs would be more honestly managed than national affairs; but precisely the reverse appears to be the case. The Congressional Library Building in Washington, the State Capitol at Harrisburg and the City Hall in Philadelphia are buildings comparable in actual value; yet the first cost $6,000,000; the second $13,000,000, and the third $25,000,000. The Congressional Library was built without graft under an officer of the Corps of Engineers, U. S. A.; the Pennsylvania Capitol appears to have been over half graft and the City Hall has never been investigated. However, in other public Philadelphia contracts that have been looked into, the amount of graft was conservatively reported to be over six million dollars on work that should not have cost the contractor more than ten million dollars to construct.

Graft begins in the municipality and spreads upward. In time it will reach the National government and the Army and Navy, after which the "debacle" is as sure as the hand of fate.

Graft in public contracts almost always involves the engineer, and the profession has no higher duty than to keep close watch of the actions of its membership in such matters. It is a field that has been neglected. Is it not time for engineers to wake up a little and formulate some ethical standards on the subject by which to judge of individuals?

The writer has had some experience in investigating things of this sort and begs to submit the following notes as to how recreant engineers can be prevented from aiding in the robbery of the taxpayers.

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In public contracts two things must ever be kept in mind: (1) The most economical price must be obtained. (2) The right of every contractor to bid and to have his bid fairly considered must be conserved.

Let us consider the processes of letting public contracts and inquire how each step must be conducted in order to comply with these principles.

ADVERTISING.

It is indispensable that all possible bidders be notified in ample time to submit bids. This should be done primarily by advertisements in newspapers and in technical journals. Small contracts are usually sufficiently advertised in local daily papers, but the notice should appear in practically all of them. If an advertisement of a New York contract appears in a Democratic paper and not in the Republican or other papers and the next contract is advertised in the Republican papers but not in the Democratic, many people will miss them. Moreover, as the policy of too many papers is more or less influenced by whether or not they get the advertisements, it would be better to boil the latter down to mere notices and require their publication in every local daily paper. The saving due to even a single extra bid on one small contract will often cover a year of such advertisements. Large contracts should be advertised in the weekly technical journals, especially those which make a specialty of keeping contractors posted on pending work.

More important than either of these should be the requirement that a list of contractors should be kept and notices of pending contracts should be mailed to every one on the list without request.

In every case of fraudulent contract that the writer has investigated, the advertising was invariably a minimum and there was no pretence of keeping an office list of contractors.

As a further check, the engineer should be required to promptly furnish to any one who asks it, full information as to the advertising of any contract, past, present or future. In every case of fraudulent contract known to the writer, the office involved has been run like a secret service bureau, where the divulging of anything official by the employees was looked upon as a serious offense, and anything like interest on the part of the public was regarded as an impudent intrusion. In this matter, it is fair to say, renegade engineers are aided by reputable engineers, who for minor reasons keep all official matters secret. After many years experience and much observation, the writer ventures the opinion that in an engineer office responsible for public work, all matters should be open to the public except those under preparation for the official action of superiors. Even this latter exception is a custom copied from military matters, where it is necessary, into civil matters, where it generally is not. A fourth requirement is that every advertisement for a contract should be posted on a bulletin-board at some designated, permanent and convenient place. The reason for this is obvious.

It is of course important that the advertisement and the specifications should be placed before bidders in ample time to give them full opportunity to make the necessary investigations and submit intelligent and well-considered proposals. The writer knows of a case where contracts aggregating $4,000,000 were advertised about 18 days in obscure papers with a resulting loss of $9 out of every $10 paid on the contracts. Fortunately the work was stopped at an early date, but even then the loss had exceeded several hundred thousand dollars.

To prescribe arbitrarily, by law or otherwise, how long each contract shall be advertised is unfortunately a difficult matter. The honest engineer frequently finds it is to his client's best interest to get the work started in a hurry, even at a greater cost; and the dishonest one can take advantage of the same idea, safe in the difficulty any one will have in impugning his judgment. It is largely a matter where, as Engineering News remarked editorially in a noted case, "The Government must trust some one." However, the enormous robberies within the knowledge of the writer which have been aided by short time advertising make it appear to him that the minimum period of advertising and the other matters mentioned should be arbitrarily fixed by law—longer periods being required for larger contracts.

To prevent combinations among bidders, and especially to prevent a favored bidder from using unfair methods, there should be no requirement which would make it necessary for a bidder to let any one else know that he is going to bid. The city of Philadelphia keeps in force an old ordinance which has no other use than to aid such corruption. It requires that with every bid a certificate must be enclosed showing that a bond for $500 has been filed with the City Solicitor. No matter if the specifications require a guaranty or a certified check for $50,000, the little bond certificate must also be with the bid. The bond itself or $500 in cash enclosed with the bid would not suffice. Should the favored contractor be a political boss, controlling all the appointments in the City Solicitor's office, it can readily be seen that no strange bidder can get in a bid without its being known in advance. And it must be several hours in advance, otherwise the clerk might be conveniently busy and the certificate not be forthcoming till it was too late to bid. It would be interesting to know the total amount that this neat little arrangement has helped to filch from the pockets of Philadelphia taxpayers.

Another means of finding out who is going to bid is to require samples to be submitted a few days in advance of the opening of bids.

Another is to so arrange that no one can bid without making special application for something. Such provisions should be forbidden.

Specifications should be distributed liberally, including blue prints where needed. Their cost is only a trifle in comparison with other amounts and with the principles involved.

THE SPECIFICATIONS.

The following essentials must be observed if specifications are to provide for fair competition:

(1) They must provide for each bidder bidding on exactly the same thing. (A case where this is impracticable will be considered further on.)

To illustrate the necessity for this, the writer once investigated a case where the contractors in collusion with the engineer fraudulently secured about $2,600,000 above fair profits largely through a provision in the specifications requiring the bidder to submit one price for three different constructions, to be used *at the option of the engineer*. The contractors and the engineer concerned have all since been sentenced to the penitentiary.

(2) The specifications must not be incomplete, vague or capable of two constructions. Such vagueness would deter bidders and would also enable a favored contractor to rob the public. An example of this is a case where an engineer first wrote his specifications calling for different prices for excavation at different depths, clearly expressed as so much for "less than six feet," so much "between six and ten feet," and so on. He revised the specifications to read so much for "excavation less than six feet" and so much for "excavation less than ten feet" and so much for "less than fourteen feet," leaving it doubtful whether or not separate prices were to be paid for different depths at the same place in a deep trench. That engineer's client, a municipality, lost at least $180,000 on that contract, largely made possible by that change from clearness to vagueness.

The investigation of a great fraud now going on has demonstrated that the bidders were required to bid on mahogany furniture by the "cubic foot." In paying the contractor, the air between the legs of mahogany tables was counted as solid mahogany, and millions of dollars were paid the contractor for such atmosphere. He is now a millionaire. What does this mean? Simply that unless forced to disgorge

he and many of his descendants, so long as they keep the principal intact, can live in luxury on the interest of this stolen money. In other words the labor of honest men and their descendants may be practically enslaved to keep that crook and his offspring forever. Such things make anarchy look respectable.

(3) The contractor should not be required to take the risk of any contingencies as to unknown conditions to be developed by the work. If the contractor is to be held responsible for the contingency, he must bid as if the contingency were sure to arise and the municipality must therefore pay for it whether it arises or not; but if the municipality take the risk, it need not be paid for unless the contingency actually arises. A contingency arising, even though covered in the bid price, can generally be used to cover fraudulent favoritism. Most contingencies can be covered by itemized bids.

(4) Nothing should be left to the "discretion of the engineer" except it be definitely stated in the specifications upon what detailed principles such discretion will be exercised.

The writer has known a contract in which there were unnecessarily reserved to the engineer discretionary action on nineteen different matters of importance. Exercised unfavorably, his discretion could increase the cost to the contractor at least 50%.

Under these circumstances, though the contract was a large one, it is not remarkable that there were only two bidders, and they were "old friends" in bidding. The engineer's estimate for this work was $3,000,000. The contractors got over $5,000,000.

In another contract, a certain privilege was denied the contractor except with the approval of the engineer. Before a stroke of work had been done by the favored contractor, the engineer gave his approval. It was worth to the contractor $107,000 in cold cash.

(5) Unit prices should be compulsory for all work subject to changes during construction. A lump sum contract coupled with the right reserved to the engineer to make changes and fix the price thereof is simply giving the engineer carte blanche in the public treasury. It is precisely the equivalent of doing the work with no specifications at all.

While in the hands of honest engineers such provisions are all right, yet they open the door so widely to fraud that engineers who prescribe them should be looked upon just as medical men look upon a doctor who advertises fraudulent remedies. The writer has investigated contracts where many thousands of dollars had been diverted into the contractor's pockets by this process.

(6) Provisions should be required in every public specifications to prevent robbery by unbalanced bids. This clumsy device has doubtless been in use by dishonest contractors and venal officials longer than the sandbag has been used by thugs, and is an even less reputable means of robbery.

It consists in the engineer or other purchasing agent very much underestimating one item in his estimate of quantities used to canvas the bids. His partner in crime bids very high on this item and low on the larger items. The small quantity called for in the estimate does not increase his bid much, so that it will figure out to be the lowest in the aggregate and he gets the contract, in the execution of which the great increase in the high-priced item makes his profits look like "frenzied finance."

Public treasuries have been robbed of untold millions by this simple process. The remedy is to forbid the increase of any item more than 10%. This provision is required in all the specifications of the Corps of Engineers of the United States Army—a body of men whose record for probity has never been equaled in the world's history. It should not detract from the dignity of other engineers to make the requirement universal.

It will occasionally happen that the quantity of some item cannot be estimated within 10%. In that case all that is necessary is for the engineer to estimate the unit prices and accept no bid that exceeds any one of them by more than 10%.

(7) Subletting of contracts should be absolutely forbidden. It frequently happens that a political boss acts secretly through an agent as a contract broker, for which service he charges what are practically enormous fees. In a case in point, the main contract would have cost $1,180,000. The contractor sublet it in its entirety, so that his profits had it been completed would have been no less than $642,000. A rather unique brokerage operation! Even where work is honestly conducted, any subletting that is done should be done by the engineer. The cost of doing it is only a trifle in comparison with the percentage which the main contractor will always add.

(8) The contract should be awarded invariably to the lowest bidder. This presupposes that the bids are all for identical articles or work. It also supposes that the bid is fortified by an adequate and reliable bond. With such a bond the personality of a bidder should disappear. I am fully aware that occasionally a work will be delayed by awarding the contract to some bidder who is habitually slow, or who is ill-equipped with plant or capital, but the specifications and the bond can be made to fully cover every contingency. Where trouble has been experienced with low bidders, it has been due to the fact that bonds have not been enforced and that penalties or liquidated damages have been used merely as threats to hurry contractors; and the remedy for these troubles has been sought in the objectionable method of ruling out the lowest bidder when he did not suit the engineer. This principle is wrong and opens the door wide to favoritism and graft. I know of half a dozen cases where a municipality lost from $10,000 to $50,000 in each case on the face of the bids by rank favoritism in the awards, for which no pretext whatever existed or was offered. When such favoritism exists in the award, you may confidently look for vastly greater thievery in the execution of the contracts.

Even if the execution of work is occasionally delayed by following the rule to always award the contract to the lowest bidder, if his bond is good, such loss measured in dollars will be a trifle in the long run compared with the financial losses that are inevitable under the other system. The moral loss caused by the increased opportunity for graft in public business cannot be measured in dollars.

(9) The names of all persons interested in the bid should be set forth in the bid itself.

This is all important. It seems to be impossible to run municipal affairs in this country except under the control of a political "boss" without official responsibility. These bosses always get rich, generally in part at least from secret participation in public contracts. The people have the right to know whether the confidence reposed in a "boss" is based, as it is often supposed to be, on his disinterested public service or on secret graft.

In a case in point, a prominent "boss" was a secret partner in one set of contracts by which $6,000,000 in loot was abstracted from the public. This "boss" dictated the appointments of all the public officials who had to do with the execution of the contracts, and even had disputed points in the financial settlement of contracts referred to him for adjudication.

Every bid, therefore, should be accompanied by an affidavit setting forth the names of every person having a present or future contingent interest in the bid, and vouchers for payment should contain similar affidavits as to interests in the contract.

With incorporated companies this would involve some difficulties and trouble, but such troubles would fade into nothingness in comparison with the enormous losses that the public has suffered by secrecy in such matters. Large corporations and trusts doubtless have features that are of vast benefit. Their injurious features are largely concerned with the secrecy as to their beneficiary personnel; and while there may be reasons justifying the failure of the state to demand in general publicity as to such personnel, there is no reason why municipalities should not demand the names of all interested in municipal contracts, whether incorporated or not.

A prominent illustration of the matter is a case where the stockholders of an incorporated company doing millions of dollars of work in public contracts, consisted of only a firm of two contractors and the engineer who represented the public.

If the engineer is not true to his duty, contractors will sometimes pool their bids, and create a competition that is apparent but not real. This is most frequent where special plant is required, as in dredging for example. However, if the above affidavit be worded to include all persons interested "by pooling arrangement or otherwise" the danger of such combination will disappear, especially in localities where the making of false affidavits is actually punished as perjury.

The writer on one occasion had reason to believe that dredge owners had combined to get high prices. Such an affidavit was called for in the proposals. There was no bid from the combine. Their dredges were all too busy! The work was done by others at reasonable figures.

The above covers the vital matters concerned in public contracts where bidders all bid on the same things. In case of patented articles, special products such as machinery, or where the quality as well as the price must enter into consideration, the only practicable method is to require that the award shall be made by a special disinterested board of technically trained men of acknowledged standing.

This subject, too, is an important one. It is a well-known fact that makers of large machinery used for public purposes maintain special selling agents who are skilled in the arts of beguiling public officials into purchases, and some of whose methods of beguilement are never published, and so far as the morals of our business youth are concerned perhaps never should be published. The above suggestion is the best remedy known to the writer, but there may be others.

If these points are all well covered in the award of contracts, there will be comparatively little fraud in their execution. Such frauds are usually made possible by double meaning or something analogous in the specifications. Beyond the requirement that public work under execution shall always be open to the public under reasonable restrictions, and that copies of the plans and specifications shall be kept accessible to the public on every such public work, little further is required.

All the above regulations can be provided by every municipality for itself. It has the right to spend its money to suit itself, subject to state regulations, and the latter usually do not forbid additional regulations. The taxpayers of any municipality whose representatives refuse to require such regulations, have a right to doubt the honesty of such representatives.

And the profession should look askance upon any engineer who does not comply with these principles, whether embodied in local laws and ordinances or not. And if any laws or ordinances interfere with the proper compliance, their existence should be noted in the specifications.

THE EXECUTION OF THE REGULATIONS.

Assuming proper laws and ordinances, an important matter is to see that they are executed. A political "boss" and his official tools can easily nullify the best regulations by ingenious complications in the specifications. The bidder can generally see through such tricks but is loth to make complaints, preferring either not to bid or to depend upon securing in some way the friendship of the boss or of the officials responsible for the execution of the contract, should it be awarded him.

One of the most difficult things to remedy in municipal contracts is the fact that bidders generally regard a public opening of bids as a sort of invitation soiree in which only the friends of the administration are expected to participate. The unsuccessful low bidder, as well as the con-

tractor who is afraid to bid, seldom feel that they have lost anything. It is the public that bears the loss.

Such bidders are therefore useless to watch over recalcitrant public officials. This should always be done by organizations of public-spirited citizens who want no contracts themselves but who do want to see that the taxpayers get proper returns for their money. Such a body can act for bidders and for contractors who are unfairly treated with a much greater show of success than the bidders themselves could possibly hope to achieve. The returns to the taxpayers would be great beyond computation. The amount that can be raised by taxation is limited and it behooves every municipality to see that its money is honestly spent.

If all the public contract money which has been stolen from our municipalities in the last twenty years were now available, what fine pavements and what clean streets we could have. What parks, what pure water and pure air could be furnished, even to the slums of our cities, could we recover the untold millions that have gone up "higher" in graft. The engineering profession is directly concerned in these things, for contract graft cannot exist if the engineer is competent, alert and honest.

The object of this paper is to induce honest engineers to put in their sepcification provisions to prevent fraud. Then dishonest ones must follow suit or be subject to just criticism. When this is done, the engineering profession cannot justly be held responsible for the acts of its recreant members, which at present is not the case.

LARGE ELECTRICALLY OPERATED GATES FOR THE ROOSEVELT DAM, U. S. RECLAMATION SERVICE.

By F. W. HANNA.*

The controlling gates being installed at the Roosevelt Dam by the United States Reclamation Service in connection with the Salt River Irrigation Project, of which Mr. L. C. Hill is supervising engineer, are the largest gates in the world operated under the pressure to which they will be subjected. The designs both for the gates and the operating devices have been most carefully worked out in every detail. The designing of the gates and appurtenances was done by Mr. F. Teichman, and that of the electrical operating and indicating devices by Mr. O. H. Ensign. The manufacturing of all of the apparatus was done by the Llewellyn Iron Works, Los Angeles, Cal., except the electrical appurtenances, which were made by the Flint & Lomax Electric Manufacturing Co., Denver, Colo.

The Roosevelt Dam, at which the gates under discussion are to be located, is situated on Salt River, at a point about 72 miles above Phoenix, Ariz. This dam is of the arched gravity type, is 284 ft. high and 644 ft. long on the arched invert. The storage capacity of the reservoir controlled by the dam is about 1,300,000 acre-feet. [See Eng. News, Jan. 12, 1905, for a description of the dam.]

The gates will be installed in the reservoir outlet tunnel which passes around the left end of the dam through a solid quartzite cliff. This tunnel is 490 ft. long and has a rectangular section, with an arched roof. It has a width of 12 ft., a maximum height of 10 ft., and its bottom is about 240 ft. below the top of the dam. Above the gates the tunnel gradually widens out into a gate chamber having a width of about 19½ ft., giving a waterway through the gates approximately equal to that of the normal cross section of the tunnel. Below the gate chamber the tunnel returns again to its normal cross section.

The gate chamber (Figs. 1 and 2) is located near the up-stream face of the dam, at about one-fourth the length of the tunnel from its upper portal. It is separated into three compartments by means of two piers that, in conjunction with the side walls of the chamber, serve as supports for the framework of the controlling gates. The partitions that form the three channels through the emergency and service gates are made up of cast iron and cast steel hollow columns, which are filled with concrete. These partitions are designed to withstand the maximum water pressure of full reservoir head, to which they will be subjected under certain conditions of the gates, as, for instance, when the outer channels are closed by the emergency gates and the middle one by the service gate.

Centrally over the gate chamber and extending the full width of it is a gallery about 20½ ft. long and 13 ft. high, divided transversely by a concrete wall into two equal parts and longitudinally by metal partitions into three equal parts. These gallery rooms provide recesses for the gates in rising.

The gates are six in number, each one being the exact duplicate of the other. They are composed of two sets of three each, the service gates and the emergency gates (see Fig. 2). The service gates are located near the down-stream end of the gate chamber and will be used to regulate the amount of outflow from the reservoir. The emergency gates are located 10 ft. farther up-stream and will be used to control the water in event of accident or repair to the service gates. The body of each gate (Fig. 3) is 11½ ft. long by 6½ ft. wide, closing a waterway 10 × 5 ft. in section. The skin plate of each gate is 2½ ins. thick, and is reinforced with horizontal ribs of the same thickness, spaced 12 ins. c. to c. The horizontal ribs have a maximum depth of 13 ins., and are stiffened with two vertical ribs, 8 ins. deep and 2½ ins. thick, each 2¼ ft. from the center line of the gate, and with two vertical ribs 12 ins. deep and 2 ins. thick, each 8 ins. from the center line of the gate in the lower portion and 4 ins. therefrom in the upper portion, where the lifting rod is attached. The total weight

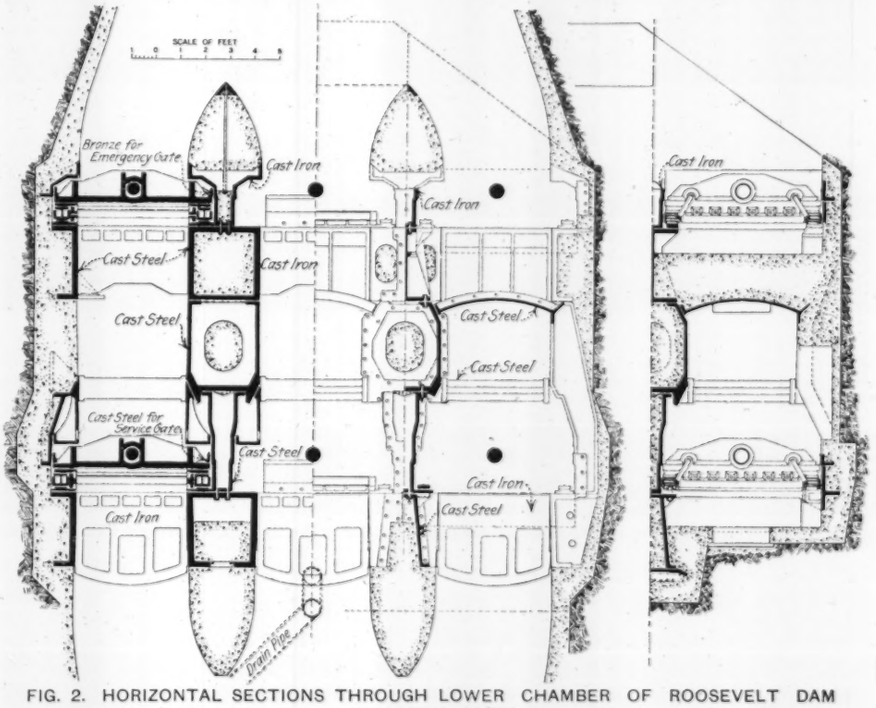

FIG. 2. HORIZONTAL SECTIONS THROUGH LOWER CHAMBER OF ROOSEVELT DAM SLUICING GATES.

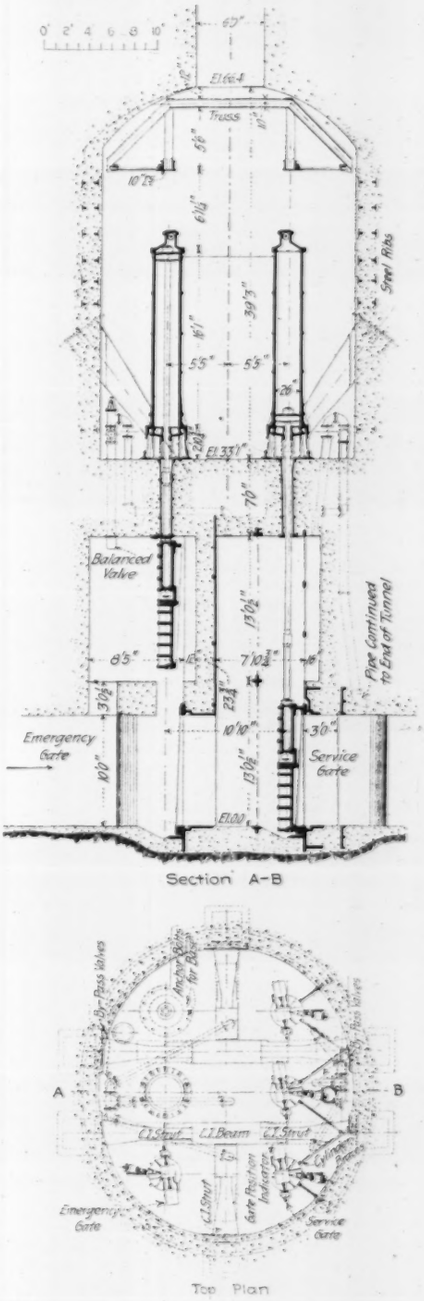

Fig. 1. Top Plan and Vertical Section Through Gate and Cylinder Chambers, Roosevelt Dam Sluicing Gates.

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of the cast iron body of each gate is approximately 15,000 lbs. Each gate is provided with a false face, consisting of a bronze seat extending entirely around the gate and a roller track on each side, all securely bound together with bronze bolts. (See Figs. 4 and 5 for details of gate seats, face, etc.) The roller track is parallel to the body of the gate, but the seat slopes away from the face from the bottom towards the top with a batter of 1 in 30. The gate frame carries a similar bronze facing, except that the roller tracks have tongues running longitudinally up their centers to engage corresponding grooves in the rollers, and that the seat has a batter of 1 in 30 in the opposite direction to that of the seat on the false face. When the gate is closed the battered faces referred to come into contact and the total pressure on the gates is borne by the seats. As soon as the gate begins to rise the weight is transferred from the seats to the rollers, on account of the arrangement of the battered faces.

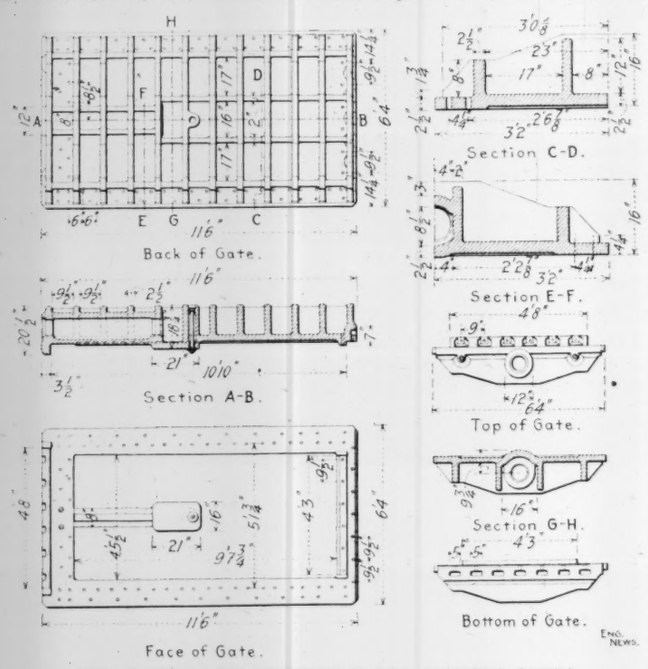


FIG. 3. BODY OF ROOSEVELT DAM SLUICING GATES.

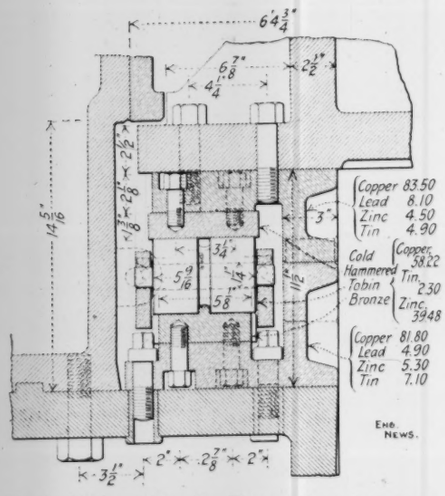


Fig. 4. Horizontal Section Through Seat, Gate Face and Rollers, Roosevelt Dam Sluicing Gates.

The roller trains (Fig. 6) are made of bronze throughout. The sides of the roller racks are held firmly in position by means of separators spaced at intervals of 18¾ ins. Each train contains 31 rollers, spaced centrally at 4⅛ ins. from each other and at 3 3-16 ins. from the separators. These rollers are 4 ins. in diameter, 5 9-16 ins. in length, and have a groove ⅝-in. in width extending around them centrally. The axis at the ends fitting into the roller rack are 1 in. in diameter and 15-16 in. in length. Each roller has to sustain a maximum load of nearly 13,000 lbs. This, it will be noted, is a considerably heavier load than a roller of ordinary bronze composition, manufactured in the usual way, and of the dimensions under consideration would safely withstand. The rollers and tracks have, therefore, been made of cold-hammered Tobin bronze, having the composition of copper 58.22 parts, zinc 39.48 parts and tin 2.30 parts. Attached to the roller train at the top is a sheave. A bronze wire rope suspended from the top of the gallery above the sheave passes under the pulley in it and engages with a bracket fastened to the top of the gate and extending out over the roller train. This rope and pulley system holds the roller train in exact position against the action of gravity in case of lack of pressure.

The total maximum pressure to which each gate will be subjected is about 800,000 lbs. This pressure produces a maximum tensile stress in the skin plates of about 2,000 lbs. per sq. in., and a maximum compressive stress in the horizontal ribs of about 4,000 lbs. per sq. in. The total estimated weight of one gate, including the bronze false face and the roller train, is 20,000 lbs. If the starting friction of bronze on bronze is assumed to be 0.4 and if the total maximum pressure of 800,000 lbs. is assumed to be acting, the friction load would be 320,000 lbs. The total resisting load would therefore be approximately 340,000 lbs.

Leading up to the cylinder chamber from the gate chamber from a point immediately above the upper central gate is an 8-in. pipe, which is connected at its upper end with three 6-in. pipes extending down into the gallery immediately below each of the upper gates. Each of the 6-in. pipes is also provided with a gate located in the cylinder chamber. These pipes form a by-pass system for each of the emergency gates, providing a means of filling the chambers between the emergency and service gates. The rate of flow of water through the system is controlled by an adjustable balanced valve, located in the initial end of the 8-in. pipe and operated at the terminal end thereof. A similar by-pass system is provided for emptying the gate chambers. The discharge pipe of this system is carried beneath the concrete lining along the side of the tunnel to its lower portal. A drain pipe carrying seepage from the cylinder chamber enters the discharge pipe of this latter system a few feet below the floor. By means of these by-passes the intensity of pressures on the emergency gates may be reduced to zero, while that on the service gates may be reduced to that due to a hydrostatic head of about 36 ft., this being the elevation of the highest point in the service gate by-pass.

The cylinder chamber is separated from the gallery of the gate chamber by means of a concrete floor 7 ft. thick, and is connected therewith only by means of the by-pass systems already referred to and the piston rod barrels, which are provided with packing to prevent leakage, and a manhole through the cylinder chamber floor. The horizontal cross-section of the chamber is an ellipse with a minor axis of about 23 ft. and a major axis of 26 ft., running transversely with the tunnel. The total height of the chamber roof above the floor is 33⅓ ft. For the purpose of supporting the floor of the chamber against the heavy loads to which it will be subjected by the water pressure in the gate chamber gallery below, four cast-iron beams are imbedded in the floor, which are connected to hollow cast-iron struts filled with concrete that rise upward at an angle of 60° and terminate with strong anchorage in the wall of the chamber. Two of these beams with a strut at each end pass one on each side of the central cylinder of both the upper and lower gate system, thus spanning the chamber parallel to its shortest diameter. Each of the remaining two beams is coincident with the major axis of the ellipse, terminates at the juncture of the adjacent longitudinal beam and is joined to a strut leading to the adjacent wall. Buried in the concrete wall and extending entirely around the perimeter of the cylinder chamber in horizontal planes, are seven compound steel ribs, composed of angles and lattice bars placed for strengthening the wall. In the upper part of the chamber is a trussed system, providing a means for handling

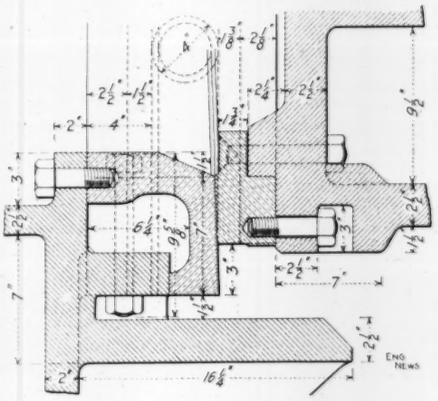


Fig. 5. Section of Lower Bar of Gate Seat and Gate Face, Roosevelt Dam Sluicing Gates.

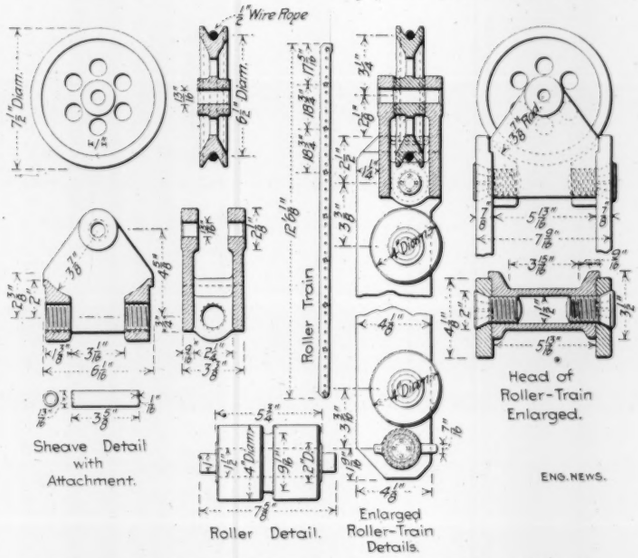


FIG. 6. DETAILS OF ROLLER TRAINS, ROOSEVELT DAM SLUICING GATES.

the heavy cylinders and apparatus in case of removal for repairs. Extending from the top of the chamber to the top of the dam is a shaft 6 ft. in diameter, for ingress and egress to and from the chamber.

For the purpose of raising and lowering, each gate is equipped with a hydraulic cylinder, designed to operate under a maximum pressure of 700 lbs. per sq. in., having a piston connected to the gate by means of a bronze lifting rod about 6 ins. in diameter and about 32 ft. long. The cylinder is made of cast iron, with a general thickness of 1½ ins. and has a brass lining 3/16-in. thick, made in sections. The upper and lower sections are fastened to the cylinder with dowel pins.

One of the unique features of the designs is the automatic arrangement for indicating the position of the piston and the gate to which it is attached. The device is equally simple and efficient. The upper cylinder head contains a bronze drum, mounted on a horizontal bronze shaft. To the upper end of the piston rod is attached a bronze wire rope, the other end of which is fastened to the drum. On one end of the shaft, which extends out of the cylinder, through a bronze gland, is mounted a cast-iron drum on which is hung a cast-iron counter weight, attached to the drum by means of a rope and pulley system. As the piston descends in the cylinder the rope attached thereto causes the bronze and cast-iron drums to rotate and raise the counter weight; as the piston rises in the cylinder the counter weight descends, causing the system to rotate in the opposite direction, thus winding the rope attached to the piston on the bronze drum. On the other end of this drum shaft is attached an electrical gate-position-indicator connected with the power-house.

The hydraulic cylinder piston (Fig. 7) is made principally of cast iron, is 2 ft. and 2 ins. in diameter and 8½ ins. in maximum depth. The piston is faced with a bronze bull ring on its contact surface. Held in place at the bottom of the piston, between a flange of the cast iron body and the bull ring, is a cup leather packing; at the top is a similar packing, engaged between the bull ring and bronze cup leather ring. The arrangement of the packing is such as to permit replacing both cup leathers from the upper end of the cylinder when the piston is in its extreme upper position.

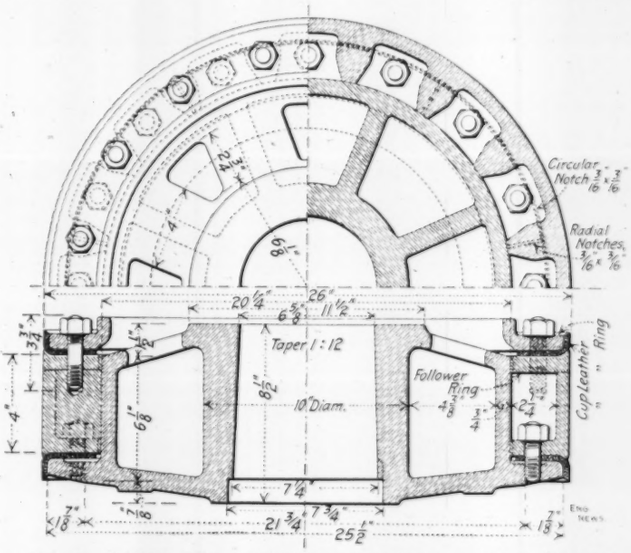


FIG. 7. PISTON FOR HYDRAULIC CYLINDER, ROOSEVELT DAM SLUICING GATES.

The hydraulic cylinders are operated by means of an electrically-actuated pump, located in a power-house situated below the dam. Two pipes are led from this plant through the dam to each of the cylinders. One of these pipes leads directly into the cylinder through a porthole at its top. The other is similarly connected with the bottom of the cylinder.

Situated in the pipe furnishing the water supply for raising the piston is an ingenious automatic cut-off system (Fig. 8) for each cylinder that stops the inflow of water just as the piston reaches its highest point and the outflow just as the piston reaches its lowest point, thus bringing the gate to rest at the proper position without the aid of the operator. The automatic cut-off system consists of a vertical 2-in. pipe, situated at a distance of about 2 ft. from the cylinder, fitted at each end with a spring valve operated by means of a lever. The fulcrum of each lever is provided by means of attachment of supports to the top and bottom cylinder heads. The top lever projects out over the top of the 2-in. valve pipe and over the top of the cylinder. The end projecting over the top of the cylinder head is weighted so as to hold the valve open, which is connected to the other end of the lever by means of a small rod. Beneath the weight attached to the lever is a small rod extending through a stuffing box into the cylinder. As the cylinder piston rises it engages this rod, lifts the weighted end of the lever, depresses thereby the other end of the lever and closes the valve. This stops the inflow of the water into the cylinder and brings the piston to rest. The controlling valve is brought slowly to its seat. A shock at the point of closure is avoided by means of a water cushion controlled in its variation by the rate of outflow from it. The valve at the lower end of the automatic cut-off is an exact duplicate of the one at the top, but is reversed for the purpose of controlling the flow of the water in the opposite direction. The lever-operating system is similar to that at the top, except that in order to hold the valve normally open the weight is placed at the opposite end of the lever. In closing the gate the water is admitted through the top inflow to the cylinder and the water beneath the piston flows out through the automatic cut-off as the piston descends. As the piston reaches the closing position it engages the small rod attached to the lower lever, depresses it, and thereby raises the other end and closes the valve. This stops the outflow of water and brings the piston to rest. The springs in the automatic valves provide for imperfect adjustments of the lever plungers and piston travels. In the pipe leading to the lower end of the cylinder is placed a relief valve, set for a pressure of about 700 lbs. per sq. in., which prevents unexpected intensity of pressure in the cylinder.

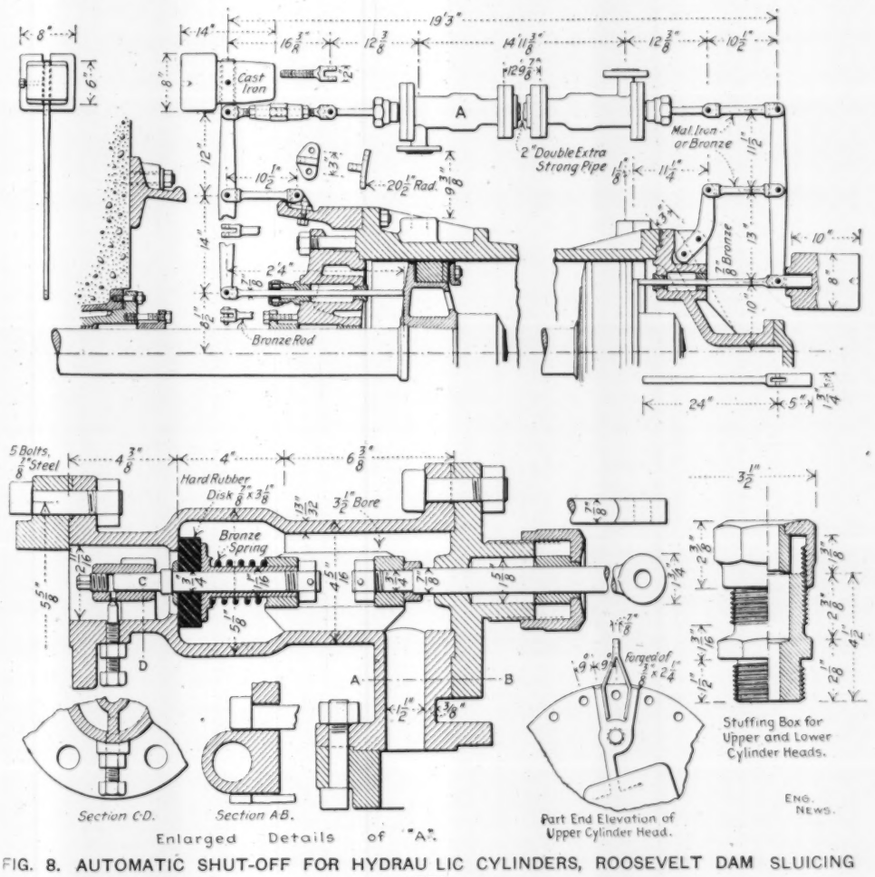


FIG. 8. AUTOMATIC SHUT-OFF FOR HYDRAU LIC CYLINDERS, ROOSEVELT DAM SLUICING GATES.

THE GENERAL ELECTRIC COMPANY'S fifteenth annual report shows the orders of last year to be $60,480,000. Six years ago, in 1900, the amount of orders was $34,350,000. The sales for the first two months of the current fiscal year are about 50% greater than the average of the past year. Expenditures aggregating $3,834,000 have been made in factory extensions. The total land area now occupied is 445 acres. Since 1903 the number of employees has increased from 18,000 to 28,000. Engineering work has been mostly devoted to extensions and modifications of existing lines of machinery, with the design of some special apparatus to meet unusual conditions.

The sizes and voltage of transformers for long distance power transmission have been increased to 7,500 KW. operating at 104,000 volts. The size of steam turbine generators is now as high as 8,000 KW. with an overload capacity of 14,000 KW. The vertical shaft design which has been successful in turbine work has been applied to the design of motor generators and rotary converters.

Orders are in for several single-phase alternating current railway equipments. Switching devices have been built for 100,000 volt lines. A new process for making a metal filament incandescent lamp of high efficiency has been developed, and a building of 60,000 sq. ft. floorage has been added to the Harrison, N. J., works for the manufacture of the new lamps.

TAR MACADAM PAVEMENT IN DULUTH, MINN.

By E. K. COE.*

Tar macadam pavement, under various names, has been in use for some years in various cities, and judging from the reports, with a varying degree of success.

In Duluth it was first tried in the fall of 1902, and in the past four years has comprised about one-half of the total yardage laid in the city. In 1906, 71,500 sq. yds. (over 90% of the total yardage laid) was tar macadam. In May, 1906, in connection with the letting of a contract for paving 13 blocks of Second St., a meeting was called of owners of abutting property, of whom over a hundred were present, as were the promoters of several competing pavements. On roll call every owner voted for the use of tar macadam. This makes it apparent that the pavement is satisfactory to those who pay for pavements here. These facts, in connection with requests from several visiting engineers, lead me to write briefly of the methods used.

The first two contracts executed in Duluth for this class of pavement were with the Warren Bros.' Co., for "Bitulithic" pavement, both being on avenues having grades of from 8% to 11.3%. The results were very satisfactory and encouraged the city to purchase a tar macadam mixing plant, and to begin preparations for laying the pavement under open specifications. These preparations were not the work of a day nor a week.

STONE.

Locally the selection of a rock for the ballast or body of the pavement was made by Dame Nature, who provided an inexhaustible supply of igneous rock. In many places in the city a quarry may be opened which will yield a rock suitable for crushing easily, either granite or a form of trap or grabbro, in any case very hard and standing high in the abrasion tests.

The first undertaking, therefore, was not a selection of the quality of stone, but of sizes. The tests and experiments made under the direction of the writer kept a careful man busy for nearly two months. The cement tester, who was also a practical concrete man, was selected for the actual work, inasmuch as a tar macadam is a tar concrete. The objects kept in view were: (1) To use the largest stone consistent with a 2-in. wearing course; (2) to reduce the voids to an absolute minimum.

A few hundred pounds of assorted sizes of crushed rock were obtained from each of two crushers located in different parts of the city; one a jaw crusher and one a rotary crusher. Screens were procured, varying by ¼-in. from ¼ × ¼-in. mesh to 2 × 2-in., and a cube mixer procured, made to order. The testing cube mixer was made of ⅛-in. sheet steel, of an exact capacity of 2 cu. ft.

Every experiment began with the introduction of 50 lbs. or more of stone passing the 2-in. screen and caught on a screen 1 in. or larger. Smaller sizes were added until the mass increased in volume. At the end of a trial the mixture was expected to fill the cube half full—the cube of course being hung on its longest diagonal axis, provided with a dust-tight sliding door, crank and standards. Any variation from the line making 1 cu. ft. was noted, and a record kept of the number of pounds of each size of stone and dust, as well as the weight per cubic foot of the stone.

By this cut and try method the voids were reduced to 7%. When the voids are filled, however, and the particles coated with tar, each particle is increased in size, so that 11% by bulk of tar seems necessary. After adopting a formula for construction work it was necessary to notice the work closely and make such changes as practical observation would dictate, as the work went on, for the first few days, on each contract, and continued observation and inspection throughout.

The following is one of the formulas that proved successful:

344	lbs.	stone	passing	1¾-in.	screen	and caught on	1-in.
152	"	"	"	1-in.	"	" "	⅝-in.
175	"	"	"	⅝-in.	"	" "	⅜-in.
275	"	"	"	⅜-in.	"	incld. very fine	dust.
54	"	tar.					

*Assistant City Engineer, Duluth, Minn.

This afforded an excess of tar, but not sufficient to prove a nuisance.

It has been found advisable to use a different mixture whenever the source of supply of crushed rock is changed, as the shape of the stone has some small effect on the proportions that will give the least voids.

TAR.

The choice of tar came by natural selection, and our experience indicates that there is less danger of a tar too soft than of one too hard. In 1904 the contractor purchased tar and pitch in barrels. These materials were combined at the mixer in specified proportions. It was found, however, that the workmen, if the inspector were absent (say at night), could not be trusted, and, the soft tar being tedious to put in, would be in part omitted. This resulted in a pavement harder than intended, more slippery, and in two cases caused a crack to appear in the pavement in the late winter. A more rigid inspection prevented a recurrence of the trouble.

In 1905 and 1906, tar from the Duluth tar plant was used. This tar is a by-product from the coke ovens, and is very uniform. For city work it is refined to sample, and is within our specifications, both at 32° F. and at 90° F.

A sample taken from the work, and several commercial samples, were submitted to Prof. Frankfurter, Dean of the School of Chemistry, University of Minnesota, who pronounced it a very high grade product.

The tar for street work is kept hot, and drawn off into steel tank wagons, which are provided with small furnaces to keep the tar melted. That which is to be used for the binder and flush coats is hauled direct to the street; that for the wearing course is hauled to the mixing plant, where it is blown over into the tank by compressed air, so the mixer is not delayed by recharging. The consistency adopted is of course softer than would be advisable in a milder climate.

The test for consistency is made on a Dow penetration machine, with the sample immersed in water at each temperature long enough to become uniformly of that temperature, and with a No. 2 sewing needle weighted and allowed to sink the required time. The penetrations noted are in tenths of a millimeter. A sample is taken every other day that the plant is running. The following are the averages of the season's run for 1906:

Deg. F.	Weight, grams.	Time, secs.	Penetration, 0.1 mm.
32	200	60	27
77	50	5	113
90	50	2	141

The specifications for tar, which have not proved severe, are as follows:

The bitumen used in this work may be prepared from either refined asphalt, natural bitumen, or coal tar, and shall have the following characteristics:

It must be free from organic matter, water, petroleum oil, water gas or process tars, or any salts soluble in water, and must be especially refined to remove the light oil, naphthaline or other matter susceptible to atmospheric influence; but must contain sufficient of its essential oils to insure the retention of its flexibility and life for a period of not less than 15 years under its exposure in the pavement. It must be adhesive, viscous, ductile and elastic.

A molded sample must retain its shape at a temperature of 90° F., and at zero F. it must not be so brittle as to break when struck by a hammer without showing distinct indentations due to the blow of the hammer. It must conform to the following requirements as to penetration, same to be determined on the penetration measuring apparatus in the office of the City Engineer, using No. 2 needle:

Deg. F.	Weight, grams.	Time, secs.	Penetration, 0.1 mm.
32	200	60	20 or more.
77	50	5	80 or more.
90	50	2	150 or less.

METHOD OF CONSTRUCTION.—The subgrade is parallel to and 8 ins. below the finished grade, and is well rolled. The foundation course is usually a 6-in. layer of crushed rock, ranging in size from 2½ to ¼-in., well rolled. This is treated with a "binder" consisting of tar, spread in the proportion of 1 gal. per sq. yd. for a crushed rock foundation, and ½ gal. per sq. yd. for concrete.

This tar is applied by means of a large sprinkling can into which the hot tar is drawn from the tank wagon. The spout of the can is flared out, and provided with an orifice about 8 × ½-in. A laborer soon becomes adept in the use of the sprinkling can and able to spread the tar uniformly. This work is in immediate advance of the spreading of the wearing course, which is made, as before indicated, by carefully proportioning rock of various sizes and tar. This work is done at the mixing plant.

MIXING PLANT.—The one owned by the city of Duluth was built by the Toledo Construction & Supply Co., of Detroit, and consists essentially of a revolving drum 16 × 4½ ft., with a firebox underneath; a bitumen kettle, which is an air-tight saddle tank, 16½ × 7 × 4½ ft., capacity 22,000 lbs., heated by 1,300 ft. of 1-in. steam pipe; air agitators; two air-tight hatches; a rotary screen; a receiving bin for each size of the screened stone; a measuring box resting on a multiple beam platform scale; a double arm rotary mixer; a bitumen bucket hung by the bail to double-beam scale, attached by roller hangers to swing crane; boiler, grates, elevators, air pump, engines, etc., all mounted on a truck.

The stone is delivered on the left side of the machine, in a stock pile roughly graded for size. One man is at the foot of the cold stone elevator and feeds in the stone as nearly as possible in the proper proportions, being guided by signals from the foreman, according to the condition of the various receiving boxes; the stone, in passing through the heating drum, is dried and heated to the proper temperature, and on passing out is elevated to the rotary screen, where it is sorted into sizes and dropped into the respective bins.

If the tar is received in barrels the tar tank is charged at night through the hatches, the consistency being had by mixing tars if necessary. When delivered in tank wagons there is no interference with the work, as the wagon is backed up to the right hand side, a hose from the top of the saddle tank connected to the wagon tank, an air hose led from the compressor and connected with the top of the wagon tank, and the tar forced over. From the air compressor, pipes lead through the furnace, to and through the saddle tank near the bottom, and are perforated so as to agitate the tar and prevent burning, and at the same time maintain sufficient pressure to force the tar out through a 3-in. pipe into the bitumen bucket, on opening a valve.

Both tar and stone are heated to between 175° and 200° F., but on no account passing 212° F., as tar burns at a lower heat than does asphalt.

An inspector is at the plant, whose duties are to see that the proportions are adhered to; that each batch is thoroughly mixed; that the materials are not overheated; and to occasionally balance the scales. Plant foremen are often tempted to use an excess of tar, making a batch appear mixed before it really is, and thus make a bigger day's run.

The mixer has a bottom dump to the wagon, and usually 6 or 7 batches of 800 lbs. each make a load. In late fall the load is covered with a tarpaulin while being hauled to the street. Dump wagons are used.

PLACING THE MATERIAL.—On the street, the load is dumped onto a sectional platform, shoveled into place, raked out smooth and immediately and repeatedly rolled with a 15-ton roller. This course, after rolling, is 2 ins. thick. When smooth and thoroughly compacted, but still hot, a flush coat of hot tar (about 5 lbs. per sq. yd.) is spread, to seal all surface voids. This flush coat is spread as thinly as possible; formerly by means of a "squeegee" (which resembles a rubber window cleaner), but latterly and preferably by means of a cart mounted on two small wheels and with a box about 18 or 20 ins. square and 10 or 12 ins. deep; a draw frame is attached forward, and behind is a piece of heavy rubber belting set on edge, about 6 or 8 ins. wide and 2½ to 3 ft. long, bent to an arc of about 60°.

In the bottom of the box is an orifice about 1 in. in diameter, with a tapering iron plug which is operated by a lever from the drawbar. Some 6 or 8 gals. of fluid tar are poured into

the box, and one man draws the "squeegee cart" over the newly laid pavement, so manipulating the plug that a small amount of tar is in a roll directly in front of the rubber. The surface is then covered with a thin layer of hot rock, of beech nut size, and again rolled.

This surface rock pulverizes under traffic to a fine dust. The dust unites with the excess of tar which squeezes out under the heavy impact of traffic, making a thin surface closely resembling an asphalt pavement, but which gradually wears down in one or two years, doing apparently neither good nor harm, and leaving the true wearing surface exposed like dressed concrete.

COSTS.—The plant owned by the city cost $10,300, has a capacity of 1,000 sq. yds. a day, has a shipping weight of 36,000 lbs., and is easily moved from one part of the city to another by means of a road roller. It is rented to contractors at $20 a day, straight time, the city furnishing the engineer. The biggest day's run was May 8, 1906, when 1,306 sq. yds. were laid, full thickness.

The work is all done by contract, on competitive bids. The average cost on the five contracts of 1906 was $1.23 per sq. yd., which includes everything above subgrade, viz.: 6 ins. of crushed rock, binder tar in place, 2 ins. of wearing course, flush coat and screenings, with a five-year bonded guaranty; the contractor to furnish labor, plant and material, and protect the city against suits for royalties.

As to its durability, 4½ years is insufficient to base an opinion, though no signs of deterioration are apparent yet.

ORGANIZATION.—The organization will vary somewhat of course, but in general, besides the force laying foundation, will consist of 1 street foreman; 3 men spreading binder; 8 shovelers; 3 rakers; 1 roller man; 1 tar heater; 1 squeegee man; 2 men spreading surface screenings; 3 to 6 teams, according to length of haul; 1 plant foreman; 1 engineer; 1 fireman; 1 mixer man; 1 weigh man; 1 feeder; 3 to 6 shovelers, according to location of the rock stock pile; 2 teams hauling tar; 2 watchmen; 1 water boy; besides administration.

This organization can get out 1,000 sq. yds. of pavement per day. A square yard of pavement, including the 6-in. foundation, requires about 3/10-cu. yd. of crushed rock and screenings, compacted to 2/9, and 3 to 3½ gals. of tar, including waste.

GENERAL.—It is not my purpose to institute comparisons between the various pavements, for each has its peculiar field, but in general it may be said that tar macadam, in Duluth at least, is not as smooth as asphalt, but is fully as smooth as brick; is about equal to either for cleanliness; is about as quiet as asphalt and much quieter than brick or stone; does not give as good a footing for teams as sandstone having a sand filler, but fully as good as brick or creosoted blocks; on account of the stone ingredient it does not soften up like asphalt in summer, but becomes fully as hard and slippery in winter.

Many of the citizens consider it equal to the expensive pavements. It is certainly adapted to districts where the abutting property cannot stand so heavy an assessment as asphalt or creosoted blocks would entail. It is in satisfactory use where some of the heaviest traffic occurs.

One source of its local popularity is due to the fact that every penny of its cost is spent locally, for home labor and home material, by local contractors; and, furthermore, it is not dependent on a promoter.

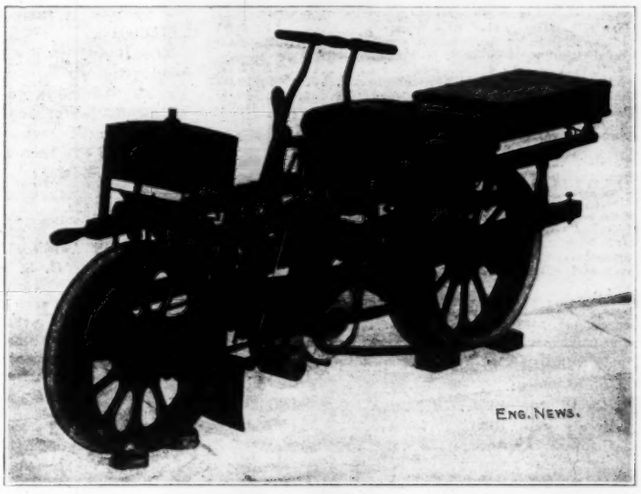
A RAILWAY MOTOR TRICYCLE; SOUTH AUSTRALIAN RAILWAYS.

The accompanying illustration shows a motor tricycle for use by Resident Engineers and District Foremen on the South Australian Railways, made by attaching a motor and gearing to the ordinary track tricycle. We are indebted to Mr. A. B. Moncrieff, Chief Engineer of the South Australian Railways for the illustration, and he writes us concerning the machine as follows:

I could not purchase a machine embodying all my requirements and was therefore obliged to modify the tricycle in use and fit it with a 2¾-HP. "Minerva" motor and gearing to suit the local conditions. Up to the present I have not attempted to put these machines into the hands of the ordinary workmen, but have placed them at the disposal of the District Foremen and Resident Engineers. They have now been in use for over 12 months and I am satisfied with the result.

The average cost of these machines has been £70, and the average cost of maintenance and working, four-fifths of a penny (1 3-5 cts.) per mile. I saw one machine a few weeks ago which had run 10,000 miles without serious repair.

You will note that there are the usual levers on the machine, so that if the motor breaks down, the officer using the tricycle can work his way to assistance, the lever being also used when starting the machine.



MOTOR TRICYCLE USED ON THE SOUTH AUSTRALIAN RAILWAYS.

Whether the time will come when machines similar to these can be placed in the hands of the ordinary workmen is to me a very open question, but for inspection purposes and in the hands of men who are capable of adapting themselves to their use I find them an unquestioned advantage. The permanent way is better inspected, with considerably less labor to the officers and with a very considerable saving to the State.

A THIRD RAIL INTERURBAN LINE has been begun in California, to be known as the California Midland R. R. The proposed route is from Marysville to Limekiln Junction, a distance of 34 miles; here the line will divide, one branch being carried south to Auburn, the other northward to Grass Valley and Nevada City; the total mileage will be about 70.

The feature of most novelty will be an under-contact third rail carrying direct current at 1,200 volts; this high voltage makes possible the use of a rail of smaller section than those in conventional use, the one proposed being of special section in the form of an inverted T and weighing but 22.4 lbs. per yd.; it will be of special low-carbon steel. It will be supported by wrought-iron stirrups keyed to the web and suspended from porcelain insulators. The insulators will be carried on iron brackets mounted on the ends of the ties. A wood covering will form some protection from the high voltage in the rail.

The operating current will be supplied by hydro-electric plants operated in the vicinity of the road by the California Gas & Electric Corporation.

The cars for passenger service will be of the conventional interurban type, 52 ft. in length. Four 75-HP., 600-volt motors, connected two in series, will drive them. As a safety device to prevent trouble in case of the slipping of one motor in a pair, the motor terminals will be shunted by potential relays. For city operation, pantagraph trolleys are provided in addition to the rail contact shoes.

TESTING WITH A SCRAPER FOR OBSTRUCTIONS IN A LONG WATER MAIN.

The villages of Portadown and Banbridge in Ireland are supplied with water through a cast-iron pipe line 23¾ miles long and 9 and 10 ins. in diameter. In order to make sure that the pipes were clear anything which might interfere with the flow or with the passage of scrapers, should it be necessary to clean the pipe in after years, the contractors were required to pass a scraper through the whole length of the pipe after completion. The work is described in a paper by Mr. R. H. Dorman, County Surveyor, Armagh, Ireland, in a paper read at the Irish District Meeting of the Incorporated Association of Municipal and County Engineers, at Belfast, on May 17, and we print the following extract:

On June 25 the scraper was put into the 9-in. hatchbox at Banbridge reservoir, and started round the bye-pass with the flow from the temporary supply. After proceeding about half a mile it stopped, as a good deal of water was getting past the scraper, and it was found necessary to turn on the water from the service reservoir, which drove the scraper to the next hatchbox with only one other stop for a few minutes. The scraper brought out at the hatchbox a stone 6½ ins. by 5½ ins. by 3 ins., and two strips of lead cut off from the pipe, which had been run in at some joint. One was 17 ins. by 1 in. by ¼-in., the other 6 ins. by 3 ins. by ¼-in. It was probably these last that caused the stoppage.

The 10-in. scraper was then put into nearest hatchbox to Banbridge on 10-in. main. It got lost passing under public road close to Banbridge reservoir, as a horse came along the road, and owing to the noise made, the scraper could not be heard, and during this interval it got stuck. Owing probably to sudden stoppage, as it was now moving rapidly, two pipes behind burst and had to be replaced. The scraper was located by sending a good flow through the pipes and carefully searching the ground with the stethoscope. When cut out it was found that the scraper had two pieces of wood, one 2 ft. by 4 ins. by 2 ins., the other 9 ins. by 2 ins. by 2 ins., wedged between it and the sides of the pipe. After the main was made good the scraper was again sent through, stopping a little further on than where first cut out and bumping for a little, finally bringing up a piece of lead about 3 lbs. weight.

Going back to the 9-in. main, the scraper was passed through the second section from Banbridge reservoir, and had to be cut out on three occasions through lead having been run in at joints. Two of these indicated gross carelessness in running the joint, the weights of lead inside pipe being respectively 32 lbs. 10 oz., 5 lbs., and 25 lbs. This lead, of course, was not in a lump, but had run along the bottom of the pipe.

The passing of the scraper through the third section of the 9-in. main led to a very interesting burst pipe. The scraper had passed this pipe about 100 yds., when a circular piece, about ¾-in. diameter, was blown out of the pipe on the scraper stopping. On examination it was found to be honeycombed rather badly where the piece was blown out, and yet this pipe had stood the test on the works in England and the full pressure of the main up to that time. The scraper had to be cut out once on this section owing to some road-metal which had got into the pipes.

On the last section of 9-in. main the scraper had to be cut out once, as some stones stopped it at a bend.

The work on the second section of 10-in. main above Banbridge was rather uninteresting, the only incident being that the scraper struck some obstruction going up a hill, and stopped. The sluice-valve behind was shut and a scour opened, which caused the scraper to come back a few yards downhill. On putting on the pressure again it took the obstruction with it, when it was discovered to be a piece of wood 2 ft. 6 ins. by 6 ins. by 3 ins.

On the third section of the 10-in. main the scraper had to be cut out once, owing to the fact that 26¼ lbs. of lead had been run in at a joint. The scraper got lost on this section, owing to some of the men turning on the water to the scraper on a wet day with a strong wind, when, of course, it was almost impossible to follow the scraper, owing to the noise of the wind and rain.

They assumed it was stuck where they last heard it, and went off home. On trying to find if it was there the next day with the stethoscope, it could not be detected. As there was the chance that it might be anywhere along the two miles intervening between that point and the next hatchbox, the 9-in. scraper was put in, and followed so as to find if the other was stuck. However, on the storage side of Edenagarry relief tank the 10-in. scraper was found by a man placed ahead. The 10-in. was taken round the bye-pass at the tank, and driven with the water in the tank to the next hatchbox. The scraper brought out on this section six small stones and a piece of wood.

As there appeared to be something wrong with the top section, extending from the storage reservoir to the Bann crossing, this was gone to next, and the results obtained on it repaid the trouble expended on the whole line. It was a rather long section, being over 4¾ miles between the hatchboxes. Two ordinary cut-outs were necessary on it, one caused by lead run in at a joint, the other by a piece of pipe sticking out from the side, where it had been caught in the driving of a turned and bored joint. A third cut was made, although the scraper had not been stopped, and was caused by the following circumstances. About 1½ miles from the storage reservoir, the scraper could be distinctly heard to strike some large obstruction, and then come on, driving it ahead. A little time afterwards, the obstruction appeared to have got ahead, as the men following it each thought that they heard the scraper, there being as much noise at one place as the other, although sometimes 100 yds. apart. Coming to Loughanlea Hill, the scraper overtook the obstruction, and they commenced to ascend the hill together with short stops at intervals. As it would have been dangerous to let them go down to the heavy section, they were stopped on the top of the hill. On the pipe being opened, it was found that ahead of the scraper, and having been driven by it for presumably three-quarters of a mile, were several large stones, evidently maliciously placed in the pipe. One was roughly spherical, 8½ ins. diameter, another 12 ins. by 5 ins. by 5 ins., and a number of others not quite so large, together with a steel jumper about 3 ft. by 4 ins. long, the total weight of stones and jumper aggregating 120½ lbs. How the scraper, driving these ahead uphill, got round a bend, is rather a mystery.

The work was completed on Aug. 24, two months after it was commenced. During this time scraping was not engaged in constantly, as the towns having to be kept supplied, Saturday was usually reserved for other work. A good deal of finishing up of work was done, as well as making good the bursts on the main. Time was lost to some extent in moving about from section to section. The scraper was sent through the main again if pipes had to be replaced behind it.

In all the scraper was cut out ten times in the 23¾ miles, six of the cut-outs being caused by lead run in at joints, and the remainder by obstructions in the pipe. Of these last four one or two could, perhaps, have been avoided, but it would have been at the risk of injuring the pipe line.

No trouble was experienced in getting the scraper through the few bends used in the main.

While passing the scraper through the main four of the 10-in. and five of the 9-in. pipes burst. Three lead joints required slight restaving, and one leaking turned and bored joint was run with lead. Of the pipes which burst, one was a defective casting and the other had probably got injured previously in transit or otherwise, the rust on a portion of the cracks showing that it had previously existed, in some cases halfway through the metal.

COST OF CONSTRUCTION AND OPERATING EXPENSES OF THE MUNICIPAL ELECTRIC LIGHTING PLANT AT BURLINGTON, VT.

The municipal electric lighting plant, of Burlington, Vt., was authorized by the City Council, in 1904, and Prof. W. H. Freedman, M. Am. Inst. E. E., of Burlington, was retained as Consulting Engineer. The building contract was let to a local builder on a "cost-plus-10%" basis. The contract for the entire steam and electrical equipment was awarded to Bellman & Sanford, of 149 Broadway, New York City.

At the outset, the important question arose, whether the city could exercise the right of "eminent domain" to secure the use of existing poles in the corporate limits. The clause in franchises providing for free attachments of all municipal signal wires, was claimed as establishing precedent for free attachment of all municipal wires. However, instead of taking the question into the courts, a compromise was effected whereby the city pays a rental of 20 cts. per attachment per year.

The first equipment of the plant was in brief: two Atlas 150-HP. water tube boilers; Sturtevant induced draft and economizer plant; two Crocker-Wheeler 125KVA., 2 300 volt, alternators direct connected to Watertown, 200 HP., 257 RPM., compound, slide-valve engines; one Wheeler jet condenser; three Westinghouse constant current transformers, of 100 arc capacity each; 218 Westinghouse enclosed arc lamps. The cost of this installation is segregated in Table I.

TABLE I.—Cost of First Installation.

Building	$8,899.75
Machinery	20,929.12
Line and Lamps	21,073.39
Consulting Engineering	2,972.94
Total	$53,875.20

The service was entirely satisfactory after the plant assumed normal running condition. The lights are operated from dusk to dawn with no "moonlight schedule." Altogether 16 street and 13 commercial arcs have been added since the original plant was started, making a present total of 247 lamps on six circuits. There was from the first some demand for incandescent lighting service, for city buildings and by persons dissatisfied with the private service in the city; $5,000 was appropriated by the City Council and a few constant potential lines were strung, until the combined load of arc and incandescent service was such that it seemed best to install additional generating equipment to insure continuous service. In April, 1906, the contracts were let to the manufacturers, for the installation of machinery for this, at the prices shown in Table II. No intermediate contractors were concerned in the work. A large amount of construction was done by the superintendent of the plant under minor contracts, and by his own force. The entire cost of the plant to Jan. 1, 1907, is given in Tables II. and III.

TABLE II.—Additional Equipment and Costs.

1 300 HP. Atlas water tube boiler	$4,125.00
Sturtevant induced draft and economizer plant.	2,200.00
1 Westinghouse 300 KW. turbine generating unit	12,369.00
1 Wheeler jet condenser for turbine	2,119.00
1 35 KW. Westinghouse rotary converter	1,114.00
Switchboard	510.00
Piping, wiring transformers and small machinery by superintendent or minor contracts	21,990.14
Total	$44,427.16

TABLE III.—Segregation of Station Cost to Jan. 1, 1907.

Buildings	13,482.60
Steam equipment	29,081.01
Electrical equipment	17,081.79
Street lighting system	21,572.27
Commercial system	16,796.79
Tools and office fixtures	289.88
Total	$98,302.34
Appropriations, bond issues and premiums	$108,592.53
Unexpended balance	$10,290.19

The liabilities incurred by the city in building the plant were:

Bonds due 1934	$58,000.00
Bonds due 1936	39,000.00
Council appropriation	5,000.00
Total	$102,000.00

Of this sum $3,697.66 has never been expended and with $6,592.53, premiums on the sale of bond issues, lies at the credit of the electric light department, making a reserve capital of $10,290.19.

TABLE IV.—Operating Expenses and Income for the Year 1906.

Expense Generating Plant.	Fuel	$7,642.41
	Labor	3,467.23
	Supplies	584.39
	Repairs	310.48
	Total	$12,004.51
Expense Distribution System	Supplies	$116.67
	Repairs	1,797.88
	Labor	1,000.69
	Total	$2,915.24
Administration Expense	Office Supplies, Telephone, etc.	612.20
	Salaries	1,533.33
	Advertising	89.15
	Interest on bonds	3,100.00
	Total	$5,334.68
	Grand Total	$20,254.43
Operating Income	Street lights	$16,103.33
	Commercial lights	7,612.76
	Accounts receivable	420.09
	Supplies and labor sold	50.22
Total		$24,186.40
Net gain of income over expense		$3,931.97

TABLE V.—Comparison of Income and Cost for the Year 1906.

Operating income	$24,186.40
4% interest on reserve	411.61
Total income	$24,598.01
Operating cost	$20,254.43
For depreciation fund	1,981.19
Total operating expenses	$22,235.62
Balance as profit	$2,362.39
Profit in % of liabilities	2.15

TABLE VI.—Increase in Commercial Service.

Receipts, month of January, 1906	$377.60
Receipts, month of February, 1906	$474.53
One month's increase in per cent. of January receipts	25.5
Receipts, month of January, 1907	$1,225.10
Per cent. increase over January, 1906	223.5

The operating cost of the plant for the year 1906 is given by Table IV. and the operating income, in Table V. A net gain of $3,931.97 over expenditures is shown, which would be 4% interest on the cost of the plant, $98,302.34. This is claimed by the Electric Light Commissioners as the profit which the plant earned, but it cannot justly be that amount. These figures follow the system of city accounting of Burlington, except that fuel on hand Jan. 1, 1907, appearing on the city accounts as operating income is here deducted and does not appear in either expense or income tables.

The city system does not include any depreciation in value of the machinery. A charge has here been figured as that sum, which annually placed on interest at 4% will amount to $58,000.00 in 27 years, and to $44,000.00 additional at the end of 29 years. Such a sum is $1,981.19 for 27 years, and $798.78 for the two years additional. At the ends of these terms, the bond issues will have been met from receipts, and the plant will be entirely solvent, whatever value the machinery may have at the end of these terms. This method of figuring the profit earned by the plant seems more accurate than that of the Board of Commissioners. The earning by this, is then 2.15% of the entire liability, $102,000.00.

The Board of Electric Light Commissioners is conducting an advertising campaign for its commercial service in an endeavor to place the plant on a still better paying basis. When this service was first installed the receipts were very small, but the increase has been considerable as Table VI. shows.

TESTS OF A 500-KW. STEAM TURBINE were recently made by H. L. Rice, General Manager, and Mr. W. M. Willett, Electrical Engineer, of the Western United Gas & Electric Company, in that company's plant in Aurora, Ill. The turbine is an Allis-Chalmers-Parsons standard horizontal turbine, rated at 500 kilowatts. The generator is a standard Allis-Chalmers turbo-alternator, direct coupled to the turbine, and rated at 500 kilowatts. The condensing apparatus is of the Allis-Chalmers standard turbo-jet type.

The characteristics of the unit are as follows: Rated capacity, 500 kilowatts; speed, 3,600 R. P. M.; frequency, 60 cycles; winding, 2 phase; E. M. F., 2,200 volts; current per phase (normal), 114 amperes. The turbine was built to operate normally with steam pressure at 140 lbs. per sq. in. gage pressure at the throttle, and a vacuum of 28 ins. of mercury, referred to a 30-in. barometer, at the exhaust nozzle. The unit is calculated to carry an overload of 50% when operating under the above steam conditions and at 100% power factor.

The time during which the turbine could be spared for test was limited from midnight Saturday to midnight Sunday; it was therefore decided to run only two tests, viz., one at 10 to 15% overload, and one at three-quarter load. The following are the results of the first test:

Average load	570.8 KW.
Per cent. of rated load	114%
Duration of test	4 hrs.
Steam pressure at throttle	143.3 lbs. gage
Steam pressure at inlet	123.02 lbs. gage
Vacuum at exhaust	26.77 ins.
Barometer	29.5 ins.
Vacuum corrected to 30" barometer	27.22 ins.
Revolutions per minute	3,600
Temperature of feed water	78.8° F.
Total water used, corrected for temperature	48,544 lbs.
Drips from steam header	318.75 lbs.
Drips from steam separator	68.25 lbs.
Boiler leakage	1,927 lbs.
Moisture in steam, by calorimeter	5.12%
Actual weight of water chargeable to turbine	43,878.23 lbs.
Actual consumption of dry steam per KW. per hr.	19.21 lbs.

The results of the second test are as follows:

Average load	385.8 KW.
Per cent. of rated load	77.5%
Duration of test	4 hrs.
Steam pressure at throttle	142.4 lbs. gage
Steam pressure at inlet	87.0 lbs. gage
Vacuum at exhaust	27.57 ins.
Barometer	29.45 ins.
Vacuum corrected to 30" barometer	28.08 ins.
Revolutions per minute	3,600
Temperature of feed water	83.16° F.
Total water used, corrected for temperature	34,552.0 lbs.
Drips from steam header	397.0 lbs.
Drips from separator	91.5 lbs.
Boiler leakage	1,927 lbs.
Moisture in steam, by calorimeter	4.48%
Actual weight of water chargeable to turbine	30,612.01 lbs.
Actual consumption of dry steam per KW. per hr.	19.83 lbs.

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A good illustration of the impossibility of permanent competition in street railway service is furnished by the two competing companies which planned each a four-track railway in New York City to extend from the Harlem River easterly to the Connecticut State line. These two companies were the New York, Westchester & Boston Ry., which received a franchise in July, 1904, and the New York & Port Chester Ry., granted a franchise in June, 1906.

At the time the franchise to the Port Chester Company was granted, it was believed that these two companies would be competitors, their routes within the city passing through the same section of the city, and a large portion of their proposed routes beyond the city limits were also parallel and close together. Clauses were inserted in each of the franchises that neither should be assigned, sublet, consolidated or merged without the consent of the city.

Notwithstanding these "iron clad" restrictions to prevent consolidation, and compel competition, both franchises are now controlled by a company known as the Millbrook Co., and as one man is president of both the Westchester and the Port Chester companies, not even a pretence that there is to be competition is maintained. A letter from the President, Mr. Marsden J. Perry, to the Board of Estimate follows:

"Inasmuch as it is apparent that two four-track railroads are not needed to serve the territory covered by the routes formerly laid down by the Port Chester and Westchester railroads, it has been decided to construct one railroad under the charter of the franchise of the New York and Port Chester R. R. Co., the legal status of which has been fully established. Should it appear upon the termination of the suit to test the validity of the Westchester charter that such charter is valid, it might then become necessary for the Westchester and Port Chester companies to consolidate or merger their interests in some manner not necessary to determine at this time. As only one railroad will be constructed, and that railroad is likely to be constructed under the Port Chester franchise, an application probably will be made to the Board of Estimate and Apportionment for a reduction of the compensation paid by the Westchester Company under its franchise.

It is undoubtedly to the interest of the public that millions of money should not be wasted in needless duplication of railway facilities, and the consolidation is much better made now than after construction of the two competing lines had been far advanced or completed. The point we would emphasize, however, is that the franchises for the competing lines should not have been granted nor should the State Railroad Commission have given its sanction to the issue of millions of dollars of stocks and bonds by these rival enterprises as it did.

Fire underwriters, as might be expected, generally favor municipal rather than private ownership of water-works. The admirable series of reports on water-works, fire, building, and electric wiring departments of cities, issued by the late Committee of Twenty of the National Board of Fire Underwriters (135 William St., New York City), contained a set paragraph stating why municipal ownership was considered preferable by the fire protection interests. The successor of the committee named (Committee on Fire Prevention) issues similar reports on cities, but in condensed form.

The latest of these which has come to us deals with a city where the water supply is furnished by a private company. In making their investigations in that city the representatives of the committee were denied information regarding water consumption, water pressures, fire hydrants and gate valves, and were not allowed access to the map of the distribution system. Perhaps this treatment was partly or wholly due to the fact that the legislature has authorized the city in question to vote bonds for municipal water-works. Such conditions might perhaps justify the company in withholding information, but if so, do they not strengthen the argument for municipal ownership?

The investigations made by the committee named make for safety of life and property and for reductions in insurance rates. Public interest demands that such studies should be aided instead of hindered by water-works officials. That there is something wrong in the city in question seems to be shown by statements in the report to the effect that the fire protection now afforded by the works of the water company is inadequate and that the city has been compelled to extend the water mains and add to the hydrants at its own expense. It is not to be wondered at that the committee recommends

that, as a step towards securing good fire protection, the city acquire absolute control of the water-works, through municipal ownership or other effective means.

The obvious duty of a water-works company to the public is to provide adequate service and also to supply acredited authorities with all needed data on that subject. If conditions are likely to arise which render such information injurious to the company then, as we have suggested, all the more reason for a change to municipal ownership.

Fairness compels us to state, in conclusion, that several other essentials to fire protection, quite within the control of the city in question, have been neglected by it. If all the facts were known it might appear that a more efficient municipal government could have secured better service from the water company.

The topographic survey sheets issued by the U. S. Geological Survey are designated, as most of our readers know, by the name of some well-known place or feature upon it. To most users of the maps, this system of designation is doubtless superior to any arbitrary system of designation by numbering or lettering. Where a large number of maps are kept on file, however, the need has developed for some system of numbering and recording which will determine the order in which maps should be placed in a drawer, for example, and will facilitate reference to a particular map.

Mr. W. S. Dix, of New York City, has recently suggested to the survey a system of numbering as follows:

The number of sheets comprised in a rectangle 1° in length and 1° in breadth is 16 or 4, according to which of the two usual scales is used. I would, therefore, suggest that the sheets be arranged in groups of 4 or 16 sheets, each, each group definitely located by the degree of latitude and the degree of longitude, passing through its center, and any sheet of the group located by one of the numbers 1 to 16 for the large scale sheets, and by A, B, C or D, for the small scale sheets. The numbering in the group would be similar to the Township section numbering of the U. S. Public Land System. For example: The Saratoga sheet of New York State would be designated by 43-74-7. Watkins Glen would be designated by 42-77-A.

A further suggestion is that the number be placed in one of the lower corners of the sheet in conspicuous heavy faced type for ease in finding in filing drawers, now a very difficult matter.

We understand that the State Engineer of New York has already adopted a system of numbers for the atlas sheets in that State, and it would seem desirable that the matter of adopting some convenient system of numbering, without, however, abandoning the present designation of sheets by name, should be taken up by the Geological Survey.

The meeting last week of the National Fire Protection Association illustrated a current tendency of technical societies. A portion of the work of all such bodies consist in fixing certain "standard requirements" for materials, devices and methods used in industrial development. To a large extent these requirements cover special phases with which each body is peculiarly fitted to deal, but very often the requirements of different bodies overlap and conflict more or less. The evident confusion growing out of such conflicting standards has led to conferences between the different associations with the object of reconciling differences. The excellent results of such conferences are well illustrated by the remark of a prominent Portland cement manufacturer, at the meeting last week. He said in effect: "These movements for uniformity of standards are right. Four years ago, the walls of all the cement factory offices were covered with specifications. There was no need for wall paper. Now that is changed. We have one standard, thanks to the conferences of those bodies interested in cement and concrete."

At the meeting of the Fire Protection Association, several requirements were presented which, while drawn for fire protection, conflict more or less seriously with other existing rules. These were referred to conferences where differences will doubtless be harmonized and a standard which will best meet conflicting requirements will be adopted.

HONESTY IN PUBLIC CONTRACT WORK.

There is no more important question to the public or to the engineering profession, at the present day, than the question how public work can be honestly executed. We present to our readers this week a discussion of this subject by Major C. E. Gillette, late of the Corps of Engineers, U. S. A., and his paper is one well calculated to set engineers thinking. Major Gillette's thesis, briefly summed up, is that all honest engineers ought to follow such methods in their contract work as are calculated to make fraud in contract letting and execution impossible, or at least exceedingly difficult. If honest engineers will use and countenance only these methods, says Major Gillette, then dishonest engineers—or shall we not rather say, grafters posing as engineers—cannot use the common tricks for defrauding the public without placing themselves at once under suspicion and setting on foot investigations that will checkmate the fraud before it is accomplished.

Major Gillette urges honest engineers to do this on the high ground of duty to the public and to the profession. We urge them to do it for their own protection as well. Many an engineer, absolutely honest and honorable, has been so confident of his own reputation that he has attempted to carry on public work with no more thought of appearances and no more safeguards against possible charges of malfeasance in office than would be necessary in work done for a private party. Too frequently have such engineers had bitter occasion to regret some act of theirs which could be construed to their discredit, although the act may have as a matter of fact been entirely innocent and have harmed no one.

We do not mean to say, of course, that it is possible for an engineer absolutely to protect himself from those who would maliciously destroy his reputation; but he should at least refrain so far as possible from putting weapons into their hands.

From this point of view, therefore, it is well worth while for engineers engaged in public

work to read and carefully ponder Major Gillette's discussion; and, by the way, why should we limit it to engineers engaged in public work? Is it not a fact that a very large proportion of the work done by engineers for private corporations is actually public work and ought to be governed by the same laws and customs to protect against fraud?

We seem to remember no long time ago an investigation of a great corporation, where very many men had their reputations smirched as badly as if the work had been done for a city or a state.

The fact is that the engineer doing work for a railway or a gas company or any other "public utility" corporation is accountable to the public. The time is rapidly approaching, if it is not indeed already here, when the law will require the same publicity in letting contracts by a railway company or an electric lighting company that it does in the case of a municipality.

The public is demanding, and properly demanding, publicity in the affairs of all public corporations. Nor need we confine it to the so-called public utilities. When a corporation reaches the position attained by many of the great industrial combinations, it has not the same right of privacy that belongs to the individual carrying on business in his own name. The officers and the professional experts whom they employ are actually trustees, in the first instance, for the thousands of stockholders whose property they are managing, and in the second instance for the far larger public to which the corporation renders service.

It may be a novel idea to some that a manufacturing corporation is as accountable to the public as a railway corporation for the efficient and honest conduct of its affairs; but when a manufacturing corporation gets an entire industry within its grasp, it stands in a wholly different position from the small independent producer. If the steel rails which it produces break in service, because it has refused to follow the specifications of the purchasers, and has furnished only the rails that it could produce at least expense and with greatest profit, the public, whose lives and limbs are imperiled, will surely find a way sooner or later to protect itself.

This, however, is somewhat of a digression from our topic. The point we wish to emphasize is that many private corporations ought to let contracts to-day with just the same publicity and just the same safeguards against fraud that surround a city's contracts. Engineers ought, for their own sake, for the sake of the profession, and most of all for the furtherance of good public morals, to use all their influence toward this end. Progress in this direction is unquestionably being made; it is much more common now than twenty years ago to find a private corporation publicly advertising its contracts. But greater progress will be made as soon as the public becomes educated to the advantages of real publicity in corporate affairs. Suppose a Board of Directors were to adopt a resolution requiring all contracts let by the company to be publicly advertised, and publicly let. Would it not be at least an entering wedge toward splitting up the illicit combinations by which money is made by insiders at the expense of the stockholders?

We are well aware that many will read Major Gillette's paper and raise the familiar objection that you can't make men honest by any process of law. It will be said that given a dishonest contractor and a grafting engineer and they can get around any sort of law that can be enacted and all the requirements that Major Gillette enumerates. We admit the truth of this and yet the fact remains that the safeguards he has set forth do make grafting more difficult and do in this way act as an effective deterrent. There are plenty of men who are kept honest, as Mr. Dooley remarks, from fear of the police. The more difficult and dangerous stealing can be made, the less theft we shall have.

We have referred to Major Gillette's paper in its relation to engineers; but it is of as great or even greater importance to contractors. The honest contractor wants to see contract work done under exactly the methods that Major Gillette has laid down. A fair field and a square deal are what the honest contractor wants, and he can only get them when the contract is advertised, when he is given time to prepare an intelligent bid, when the specification states exactly what will be required of him and when he is not required to bear the burden of risk.

There is another reason why the subject is of importance to the honest contractor. There is a movement toward executing work by day's labor instead of by contract. Every new fraud uncovered in municipal or in state contracts give impetus to this movement. We shall not take space here to set forth the arguments against day's work or those in its favor. Enough for our present purpose that this tendency toward day's work exists and that it can only be counteracted by the cooperation of honest contractors and honest engineers to put contract execution on an honest basis.

LETTERS TO THE EDITOR.

Form for Pile-Driving Records Used on the Norfolk & Southern Ry.

Sir: In the accompanying cut is shown a sample page of the pile-driving record we are using here. On the side of the page with the drawings the recorder shows diagram of bracing, sizes and kinds of timber, distance c. to c., of bents, etc. This may be of interest to some of your readers.

Very truly,
Thos. W. Cothran,
Norfolk & Southern Ry.

Raleigh, N. C., April 27, 1907.

A Standard for Street Piping Proposed.

Sir: At the next meeting of the American Society of Civil Engineers, a petition will be presented asking for the appointment of a special committee to consider street designing with a view to recommending standard sections, by following which street piping could be laid in new streets or older ones about to be paved, either at the sides of the streets or in subways so that it would not be necessary to tear up a costly pavement to get at street piping for a mere house connection or leak.

This committee is asked for on the ground that just as architects have made house plumbing open and accessible, so street piping, which is simply plumbing of larger sizes, should be made accessible by engineers, if not for old streets, then certainly for new streets, many of which are now being laid out and improved.

To get this petition to a ballot will require an affirmative vote of not less than 25 members. There can be no doubt that a very little committee work by any of our leading engineering societies would give street designing proper recognition and bring to an end most of the constant and costly tearing up of new pavements that now prevails.

Yours truly,
Rutger B. Green, M. Am. Soc. C. E.

Care, the Solvay Process Co., Detroit, Mich., May 25, 1907.

Water Pipe Sizes in Various American Cities.

Sir: The writer has recently compiled statistics of the amount of the several sizes of water pipe in use in the following cities:

Wilmington, Del.	Boston, Mass.	Providence, R. I.
Binghamton, N. Y.	Springfield, Mass.	New Haven, Conn.
Rochester, N. Y.	Albany, N. Y.	Reading, Pa.
New Bedford, Mass.	Waterbury, Conn.	Worcester, Mass.
Fall River, Mass.	Cambridge, Mass.	Lowell, Mass.
Hartford, Conn.	Brockton, Mass.	Attleboro, Mass.
Washington, D. C.	Richmond, Va.	Troy, N. Y.
Brookline, Mass.	Holyoke, Mass.	Concord, N. H.
		Corning, N. Y.

As these 25 cities may perhaps be considered as representing the average of a greater number, the following result is given, as being of possible interest to your readers:

Size.	Percentage.	Size.	Percentage.
3 in.	.77	18 in.	.03
4 in.	8.93	20 in.	2.81
6 in.	44.98	24 in.	2.54
8 in.	14.44	30 in.	1.99
10 in.	4.00	36 in.	1.17
12 in.	12.64	40 in.	.30
14 in.	.42	42 in.	.20
16 in.	4.38	48 in.	.40

W. B. Franklin,
Sales Agent, U. S. Cast Iron Pipe & Foundry Co., Land Title Bldg., Broad and Chestnut Sts., Philadelphia, Pa., May 10, 1907.

Should a Civil Engineer Furnish His Own Instruments?

Sir: The question has arisen under what circumstances civil engineers should furnish their own instruments. I think these are generally furnished by their employers. The State of New York, however, is a notable exception. This state requires Assistant Engineers to furnish a transit; Levelers to furnish a level and Rodmen must furnish level rods. Here the requirement stops, as Chainmen do not have to furnish chains, nor Axemen axes. I understand this rule has been in force since 1817, when the Erie Canal was built. As the Engineering Department is now organized, Assistant Engineers and Levelers very rarely use their own instruments, but the work with them is done by one of their subordinates, who are in no way responsible for their use, damage or repairs.

So far as my experience goes, all companies, corporations, municipalities, governments, etc., furnish instruments, but I would be glad to learn through your influential journal what the general practice is.

Yours truly, P. A. Ragon, C. E.

Syracuse, N. Y., May 20, 1907.

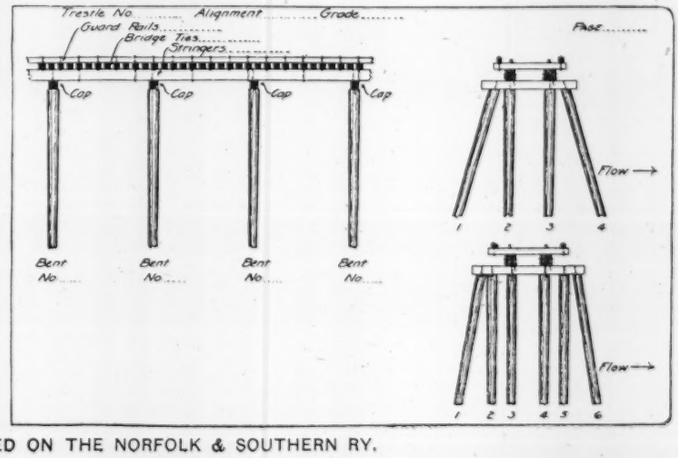
[Of course, engineers carrying on their own business furnish their own instruments, and

NORFOLK & SOUTHERN RAILWAY COMPANY

PILE-DRIVING RECORD. TRESTLE NO. _____ ACROSS _____

RESIDENCY, _____ DIVISION, _____ CONTRACTOR _____ RECORDER

Date	Mile / Station	No. of Bent	No. of Pile	Kind of Timber	Length of Pile	Diameter of Butt	Diameter of Point	Length below Cut off	Length of Cut off (Waste)	Depth of Water	Distance Driven	Elevation of Top of Pile	Elevation of Point of Pile	No. Blows	Fall of Hammer	Weight of Hammer	PENETRATION FOR EACH TEN CONSECUTIVE BLOWS (In Inches) 60	50	60	70	80	90	100	110	120	130	140	150



FORM FOR PILE-DRIVING RECORDS USED ON THE NORFOLK & SOUTHERN RY.

hen such an engineer is elected to the office of unty Surveyor or City Engineer, or is emoyed to locate a small railway line, he still conues to use his own tools. It is only the larger ties and the larger corporations which maintain permanent engineering force that undertake to pp'y the instruments.—Ed.]

Test of the Comparative Efficiency of Large and Small Well-Drilled Holes for Heavy Blasting.

Sir: Since railroad contractors have adopted well rillers for blast hole drilling, there has been differences opinion as to the best size of holes to drill, to give the st results in springing and shooting; also, for comrative speed and cost of the drill work itself.

The Winston Bros. Co., desiring to test this matter in thoroughly practical way, had two drills shipped to Hell Gate, Montana, where they have a large contract nd a number of very heavy cuts to make in solid rock. ne of these machines was equipped with solid rods for rilling 3-in. holes; the other was equipped with a heavy tring of cable tools for drilling 5-in. holes. The Keystone driller handling the cable tools drilling the 5-in. holes was of the traction type, and the Cyclone driller, handling the rod tools drilling the 3-in. holes, was of the non-traction type. This item was perhaps overlooked in ordering the drills, as it did not put the two machines on an exactly equal basis. When moving from one hole to another, the traction machine had considerable advantage over the other, as it was able to move in less time.

The drills were started on two lines of holes parallel with each other and 20 ft. apart; the rod drill gained rapidly on the cable drill, finishing its line of holes and drilling one hole on the line of the cable drill, which was an actual gain of two holes. Had the rod machine been a traction outfit, considerable more time could have been made, as it required more time to move the non-traction than it did the traction drill.

The holes were sprung after each machine, and the small holes were found to spring much better than the larger ones with the same amount of explosive used in both. This was due to the tamping blowing out of the larger holes, which did not occur in the smaller ones. In a number of holes it was necessary to use short pieces of drive pipe to case off the loose material above. When the shots were fired the amount of energy spent through the opening of the holes was very evident. The drive pipe in the large holes was thrown high in the air, or torn apart, while that in the small holes was not thrown up or damaged.

The result from the work done by each was very strongly in favor of the 3-in. holes. The test was carefully conducted and as the drills were operated by the competing companies, each machine was worked to its maximum capacity. The material drilled consisted of shales, limestone and conglomerate rock, all of which laid on an angle of about 30°. The best day's work for each drill was 73 ft. in 10 hours for the rod machine and 71 ft. in 12 hours for the cable machine.

In the writer's opinion, the character of this work is a fair average of what the contractor encounters in various parts of the country, and he thinks this test is of considerable value in determining the proper size of holes to be used.

Another feature in favor of the rod machine is also found in the tool dressing. The bits being small and not more than one-third as heavy as the large bits, are more easily handled in dressing, and much more convenient when they are carried to the blacksmith shop. The writer is indebted to Mr. Gus Young for the greater part of the information. Mr. Young had charge of the drill work and also the blasting.

Walter T. Kershner.

Hell Gate, Mont., May 16, 1907.

Lining Track with Jacks.

Sir: In your issue of April 25 we notice a description of a rather elaborate special jack for lining up track. It is a comparatively easy matter to line up track with an ordinary jack, such as is commonly used for raising track, and possibly your readers may be interested in a description of the method employed. Where it is desired to push any considerable length of rail over, the men are placed along the line and dig their crowbars into the gravel and push it over all together. Where there is a short section to be pushed over about ½-in., where it has worked out of line, a Joyce-Cridland track jack is placed under the track and the latter raised up enough to loosen the ties. The jack is then stood over at a right angle and the track raised up a short distance, when the rail will slip off the foot of the jack and drop into its place.

The objection to special track jacks is that one type of track is usually weight enough to be carried around. Each jack be provided with a sub-base it must have many extra parts; such as a bearing for the lever, an auxiliary lever to take the load when the lever is removed, and a sub-base for sliding the jack when shifting the track. Besides this, there is the fault of having a lever which can be removed from the jack and mislaid. The ground must be dug out to make room for the sub-base, whereas a couple of jabs with a shovel will form a foundation for the ordinary track jack when used to push the track over. Traversing jacks are useful in moving heavy machinery short distances, but to use a sliding arrangement of this sort on a track, where it cannot be lubricated, is, we believe, an over-refinement.

The Geo. H. Gibson Co.

Tribune Building, New York, N. Y., May 6, 1907.

[The method described in the first paragraph of the above letter can, of course, be employed with any make of track jack. In accordance with our practice we submitted the criticism to the makers of the jack described in our issue of April 25, and we publish their reply below.—Ed.]

Sir: Your correspondent who criticises our lining-up jack, describes a method of lining track which is familiar to railway men and others, but we believe he has misunderstood the best features of our device.

Where there is a large section force and plenty of men in the gang it is perfectly possible to get along without our lining-up jacks, as has in fact been done for many years. But there are seasons of the year when section gangs are much reduced. There are also small divisions where there is never a regular force large enough to keep track properly relined, and when the track becomes in bad condition a special gang is organized to put in order. But with our special jacks, a section foreman with one man can go along and line up the track as readily as they now tighten up bolts.

There is another desirable feature about these jacks. Removed from their bases they may be used as regular trip ratchet track-jacks, as they conform to the specifications of the Roadmasters' Association. The jacks are not devices to be used for lining purposes exclusively. As long as they may be made to perform two kinds of work, are they not of greater value? As to the inconvenience of carrying greater weight, it is, according to the writer's observation, unusual for a section gang of any size to go out with simply one jack. If jacks are needed at all, one is scarcely sufficient; two or three are loaded on to a hand-car and taken to the point of work.

As to the extra number of parts: The pawl which holds the load suspended is a simple affair which is no more objectionable than an extra blade in a jack knife. The danger of losing the lever is not greater than the danger of leaving a whole jack behind. Either is possible. The sub-base is a simple one-piece affair. As to the time required to place it under the track, I would say that where the roadbed is solid the bases can be placed, the track loosened and thrown by two men in far less time than eight or ten men can do the same work by any other method. One demonstration, for example, was where two men moved a crossing 3¼ ins. in less than seven minutes. This included setting the bases and jacks. This crossing was solidly imbedded, and the section foreman said that ten men could scarcely have done the same in that time. Another test was where a curve which was imbedded in hard cinders and had not been disturbed for 14 months, was thrown inward 2 ins. by two men in less than five minutes, which time included the setting of the jacks.

These track-lining jacks were but recently placed on the market by us, and we are receiving continued orders for them.

Yours truly,

Buda Foundry & Manufacturing Co.

C. H. Delano.

Chicago, May 14, 1907.

Building Department Regulations and Theoretical Ideas on Reinforced Concrete Design.

Sir: In your issue of April 11 a correspondent, under the caption of "Pitfalls and Variations in Reinforced-Concrete Design," has brought up many interesting questions, and winds up with the question, 'On the whole subject, what is authoritative and where can it be found?"

From the amount of test data at hand, the writer is inclined to the opinion that no work yet published on reinforced concrete can be considered authoritative, for the reason that none of the authors of these treatises, as far as is apparent from the text, indicate that they have had a sufficiently broad experience with reinforced concrete in actual construction to be competent to write authoritatively on the subject. Published test data to date have been confined very largely to experiments which, at best, can be considered mere laboratory work. Tests on simple beams and slabs reinforced in one direction have frequently been made at the various technical schools with concrete of a low grade and workmanship inferior to that which is secured with ordinary equipment in the actual construction of the work.

If we are inclined to regard building ordinances as authoritative, we should compare those of the various cities and see how beautifully they agree with each other. For example, take a building not long since put up in the city of St. Paul. This building is ten stories high; the lower columns are reinforced with eight 3-in. round rods tied together at intervals with ¼-in. wire ties, Hennebique style. The contractor who put up this building remarked that he could not help regarding these ties as something of a joke. In a measure was he not right? The Building Department of that city allowed 400 lbs. per sq. in. on the concrete and 12,000 lbs. per sq. in. on the vertical steel, and presented no rational requirement for hooping or ties, and naturally got as near nothing as possible in this line. Let us go east now and consider the Building Department of Philadelphia. This department allows 300 lbs. per sq. in. on the concrete, which may be increased to 800 lbs. by the use of hoops figured according to Considère's formula, and allows nothing whatever for vertical steel reinforcement.

Here are the two sides of the question; can they be farther apart? Which is the more reasonable position? The writer is inclined to think that neither is correct and that the strongest work results from a fair percentage of vertical reinforcement combined with a fair degree of hooping.

Take the next question, "Are beams to be figured continuous over supports?" The answer to this question, as we look at it, should be both affirmative and partially negative, dependent upon the character of the construction. For example, take the case of slab tests. We may test a single panel of a slab reinforced so that the rods are carried near the top of the slab over the beam and we get no difference in deflection between an end and an intermediate panel, unless we load the adjacent panels, for the reason that the negative moment in the center of the panels adjacent to that on which the single test load is placed is offset or taken up by the concrete only and a slight moment due to the dead weight. The concrete gradually stretches under tension until the steel in the panel is doing the work.

Now, if we are to figure beams as fully continuous, we will have the same objection to the continuous beam, except in the case where the beam is connected to the slab and where the slab is reinforced parallel to the beam. This is always the case with two-way reinforcement, and never the case, to any considerable extent, with one-way reinforcement. Nevertheless, if the work is to be put up with minimum hazard in its erection, there should be enough steel to tie the concrete together, whichever way it is put in.

Let us now consider the authoritative building ordinances for figuring slabs. Building departments, as a rule, in the majority of cities that have published regulations for concrete, are about fifteen years behind the times in their requirements for slabs. For example, where a slab is reinforced in two directions, the bending moment, according to common published rules, may be taken at Wl÷20 each way, and Wl÷10 where the slab is reinforced in one direction; in other words, building ordinances have not credited the steel running in both directions as being of any more value than as though it ran in only one direction. Let us examine the work which the reinforcement has to do in a simple span slab and the work which the reinfotcement has to accomplish in a slab supported on four sides, in terms of the distance it has to transport the load coming to the supports. In the case of the slab supported on two sides, the center of gravity of the load which travels to each support is ¼ l from the support; in other words, the product of the load times the distance from its support is W × ¼ l. In the case of the slab supported on four sides, one-quarter of the load goes to each support, if the panel is square, and the distance of the center of gravity of the load traveling to each support is ⅛ l; in other words, the work the reinforcement has to do is two-thirds in one case what it is in the other. Further, straining the concrete in several directions increases its strength, as treated mathematically in the flat plate theories. Hence, a slab reinforced in two or more directions is a matter of at least three times as strong as a slab reinforced in one direction only and supported on two sides only, as proved by numerous tests, and when the same amount of steel has been used in each case.

In this respect, the building ordinances of many cities are directly encouraging the erection of inferior and the more hazardous types of construction, in that they make no difference between the amount of reinforcement required in these extremely different cases. Thus, from the dollars-and-cents standpoint of cost of erection, regardless of risk of construction, that type of construction in which beams are run in one direction only is directly encouraged by these ordinances as against the more economical and conservative construction with beams running in both directions, through reduction of centering and cost figured on an irrational basis.

Some engineers have an idea that the results which the writer refers to—of tests of slabs reinforced in two or more directions—are due to arch action. For the benefit of these critics, the writer would say that he has tested slabs 20 ft. square, 5¼ ins. thick, with 450 lbs. of sand per square foot, over the full area, with an elastic deflection of 11-16 in.; that he has found, in slabs

approximating this size, no difference in deflection between wall and interior panels and that he has been able to reduce the deflection of the slab by loading adjacent panels, where the reinforcement was as outlined above. He has further seen slabs reinforced in both directions deflect, under test, below the bottom of the slab at the support, crack slightly, and still require a much greater load to produce ultimate failure, showing clearly the absurdity of the arch action idea.

We have recently made some full-sized tests of columns ranging in ultimate strength from 500 to nearly 700 tons, and we believe that the results of these tests bear out the opinion given regarding the combination type of hoops and a fair degree of vertical steel recommended.

The greatest trouble with the development of the reinforced-concrete industry to-day seems to lie in the fact that there is such a number of theoretical writers who possess the temerity to rush into print with theories evolved from their inner consciousness rather than by the safe and more laborious method of carefully determining the accuracy of their theoretical notions by practical experiment and justifying them by adequate test data.

The reason for the popularity of reinforced concrete lies in its economy over structural steel and the rapidity with which it may be erected. For example, a stockhouse for the Hamm Brewing Co., in St. Paul, was designed for a structural steel frame. The lower stories were needed at once; deliveries of structural steel could not be obtained under ninety days. This part of the work was completed in half that time, in concrete, at a large saving to the owner, estimated at between forty and fifty thousand dollars for the building.

Respectfully yours,

C. A. P. Turner.

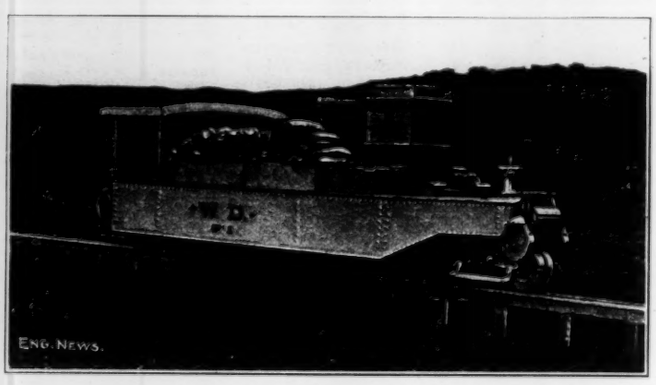
816 Phoenix Building, Minneapolis, Minn., April 24, 1907.

THE GYROSCOPE MONO-RAIL RAILWAY.

Cable dispatches from England on May 8 reported the exhibition before the Royal Society on that date of the model of a most remarkable new form of mono-rail railway, invented by Louis Brennan, C. E., the inventor of the Brennan torpedo. All previous inventors of single-rail transportation systems have either used an elevated rail and suspended car (as in the telpherage system and the Barmen-Elberfeld railway), or they have used auxiliary wheels and rails overhead or at the sides to steady the car on the single rail and prevent it from tipping over.

Mr. Brennan appears from the accounts to have invented a car which can balance itself on a single rail like a tight-rope walker, or rather with much more security than a tight-rope walker, since it does not tip over—according to reports—even if its weight is not balanced over the central rail.

The first cabled accounts of the invention were too meager for one to form any idea concerning the invention; and we have therefore awaited the arrival of the English journals, "Engineering" and "The Engineer" for more circumstantial statements of what Mr. Brennan has actually accomplished. The numbers of these journals containing the report of the Royal Society soiree have now come to hand; but still leave us much in the dark as to the exact mechanism by which Mr. Brennan accomplishes his paradoxical feat in mechanics.



THE GYROSCOPE MONO-RAIL CAR.
Invented by Louis Brennan, C. B.

We print, however, in full below the description of the invention in "The Engineer," with the illustration accompanying it. It will be noticed that "The Engineer's" account is based on examination of a working model on Mr. Brennan's estate; but its representative is exceedingly hazy in his statement as to the method by which the gyroscopic apparatus actually operates to maintain the stability of the car:

At the invitation of Mr. Louis Brennan, C. B., we recently visited his house at Gillingham to witness some trials of a new type of mono-railway, on the design of which he has been engaged for some years. This railway has been built only on a small scale, the model being one-eighth of the size of a similar railway which the inventor is at present constructing. Briefly stated, the model mono-railway may be said to consist of a circular section rail laid on wooden sleepers on the ground, or it may be laid on piles, as would be required on the slope of a steep hill, such as shown in the illustration. In places the track consists only of a stout steel rope tightly stretched to represent the construction of a bridge across a ravine. The car somewhat resembles in shape a large pontoon or barge. Part of the inside is arranged for passenger accommodation, and part for goods. The car is carried on two bogies, one at each end. These bogies are so pivoted that they allowed the car to turn easily on curves, and also vertical movement. By this means it is claimed that the vehicle can run upon curves of even less radius than the length of the vehicle itself, or on crooked rails, or on rails laid on uneven ground, without any fear of derailment.

The inventor, as is natural, is very sanguine as to the future of his railway; to use his own words:

By its means vehicles of colossal dimensions, more like moving hotels or ships on shore than the usual form of railway carriage, will travel at velocities of probably from two to three times that attainable at present; at the same time there will be a complete absence of lateral oscillation in the carriages, and a great increase in the smoothness with which they will run * * * every facility can be given for the enjoyment of life while traveling, as the carriage may be fitted up with all the comforts of a first-class hotel, and separate rooms provided for every purpose, such as smoking, dining, reading, writing, etc., even promenade and music rooms, will probably be provided to relieve the tedium of railway traveling.

Whatever we may think for or against this system for railway work in general, we cannot but admire the manner in which the inventor has applied gyrostatic principles to it.

Returning for a moment to the construction of the car. We have already stated that it is carried on four wheels. Each pair of these wheels is coupled, and one in each set is driven direct through gearing from electric motors carried on the bogies. The power for propulsion is derived from a number of small secondary cells placed inside the car. But by far the most interesting part of the carriage is the means adopted for maintaining equilibrium, for it must be at once apparent that the center of gravity of the car is much higher than the center of buoyancy, and consequently it is an unstable body. To overcome this Mr. Brennan has introduced two gyroscopes mounted on bearings which run in a partial vacuum. These gyroscopes work in a vertical plane and run in opposite directions; they are connected together by suitable gearing so that their peripheral velocities are equal. This arrangement overcomes the difficulty which would be experienced in turning were they not so constructed. Special means are provided for advancing the precession of the gyroscopes, and thereby causing them more quickly to return to the horizontal plane. It was very interesting to notice how the car, when going round a curve, leaned inwards, returning to the vertical position directly it passed on to the straight rail again. It was also interesting to notice how when a heavy weight was thrown on to the side of the car the latter rose, instead of dipping, as one would at first expect it to do. The explanation of this is simple, a recognized phenomenon of the gyroscope, and need not be entered into here. The gyroscopes were motor-driven, and ran at a speed of from 7,000 to 8,000 revolutions. This mechanism occupies little space, and it was stated that in larger cars it will only be about 5% the total weight of the vehicle.

The model was built essentially to illustrate the value of the invention for military use, and was therefore designed with a low speed—about seven miles per hour—but with good hill-climbing capabilities. The trials, which lasted for some time, were successfully carried through. The car was loaded with weights representing 20 tons, and, in order to prove its stability, a weight corresponding to that of fifteen men was thrown suddenly on to the side of the car, and as we have already stated, the side of the car on which the weight was thrown gradually rose to restore the position of equilibrium. To show how well the car could turn, an ordinary steel rope, about ⅝-in. in diameter, was laid on the lawn, and round the many turns specially arranged for the purpose the little car wended its way very gracefully. It appeared to experience no difficulty in climbing gradients of 1 in 5, and on one occasion the bank was said to be 1 in 2½; however, this was shot, and the car had a "rush" at it. But, loaded as it was, the climb up 1 in 5 was an excellent performance for so small a car. At the conclusion of the trials one gentleman, weighing nearly 140 lbs., was given a ride round the miniature track, and he finally crossed the wire bridge, which had a somewhat considerable span. That so small a car could take the weight it did and run so well shows that, whatever be the future of this type of mono-rail, there can be no question as to its success on the small line we had the pleasure of inspecting.

Mr. Brennan is at present engaged upon the construction of a full-sized vehicle, 12 ft. in length, similar, we believe, to the model just described. It will, however, be driven by a petrol engine of 100 HP. direct coupled to a motor. The gyroscopes will be 2 ft. 9 ins. diameter, and will have a speed of from 2,000 to 3,000 revolutions per minute. The road wheels will be power driven, and change gears provided to facilitate hill climbing. It will also be possible to free-wheel down hill. Brakes capable of being operated by pneumatic or manual power will be fitted to all the wheels. The inventor considers that one of the most valuable applications of his mono-rail will consist in its adaptation to vehicles of ordinary dimensions, which will serve as feeder lines to existing railways, and pioneer lines in new countries, such as the colonies. By this means, he states, it will be possible to construct lines at a minimum cost, and give settlers a means of getting their produce to market with great speed and economy.

Our illustration shows the railway constructed on the side of a hill—a construction which Mr. Brennan states is frequently required in India, where notching in the side of a hill would cause many tons of material to fall from higher up the hill-side. It is also claimed that this construction in no way interferes with the natural drainage of the land.

The account in London "Engineering" refers only to the exhibition of the invention before the Royal Society, and gives no additional information to that contained in the above. A little additional, though not very much, is contained in a cable dispatch to the New York "Sun," which quotes the inventor's own claims for his invention as follows:

The characteristic feature of this system of transport is that each vehicle is capable of maintaining its balance upon an ordinary rail laid upon sleepers on the ground, whether it is standing still or moving in either direction at any rate of speed, notwithstanding that the center of gravity is several feet above the rail and that wind pressure, shifting of load, centrifugal action or any combination of these forces may tend to upset it.

Automatic stability mechanism of extreme simplicity carried by the vehicle itself endows it with this power. The mechanism consists essentially of two flywheels rotated directly by electric motors in opposite directions at a very high velocity and mounted so that their gyrostatic action and stored up energy can be utilized. These flywheels are mounted on high class bearings and are placed in exhausted cases, so that both air and journal friction is reduced to a minimum, and consequently the power required to keep them in rapid motion is very small.

The stored up energy in the flywheels, when revolving at full speed, is so great and the friction so small that if the driving current is cut off altogether they will run at sufficient velocity to impart stability to the vehicle for several hours, while it will take from two to three days before they come to rest. The stability mechanism occupies but little space and is conveniently placed in the cab at one end of the vehicle. Its weight is also small, about 5% of the total load being considered an ample allowance for the first vehicle.

Everything points to great economy resulting from making the vehicles wider in proportion to their length than on ordinary railways, and it has therefore been decided to make the experimental wagon 12 ft. wide, or one and a half times as wide as usual. For civil work in the colonies the vehicles will probably be two or three times as wide, if not more.

Bridges are of the simplest possible construction, a single wire hawser stretched across a ravine or river being all that is necessary for temporary work. These hawsers can be built up on the spot from separate wire rope strands, so that the transportation of them becomes an easy matter. Strange to say, the lateral swaying of the hawser does not disturb the balance of the vehicles, and the strongest winds will fail to blow them off.

It will be noted that the exact arrangement of the gyroscopes which perform the wonderful feat of keeping the car balanced over its point of support is not disclosed in any of the above accounts. It may interest some of our readers who are mathematically inclined and familiar with the gyroscope to puzzle out how a pair of rotating fly-wheels can be made to prevent an unstable body from tipping over in obedience to the law of gravitation. That this seemingly impossible feat has been actually accomplished (with a small model) appears certain, if we may trust our esteemed British contemporaries. That the feat is a scientific marvel of the first magnitude will certainly be agreed by all.

Turning now to the projects for the practical application of the invention, we confess ourselves unable to see any prospect of the use of such a system of transport as a competitor of the ordinary two-rail railway. Granting all the claims of the inventor, it appears impossible that any such system could be seriously considered for a high speed line, since it would be inherently more dangerous than the ordinary two-rail system. The proposition of the inventor to operate cars of extraordinary widths on this system may also be set down as an absurdity.

The chief practical field for the invention, if the claims for it are substantiated on further investigation, would appear to be for the construction of very light, cheap lines for handling traffic of small volume. Some form of transportation line which can be built and maintained at a small cost is needed in a thousand places, as feeders to existing railways, as mining and lumber railways, as pioneer lines, for military work, for contractors' use, and on ranches and plantations. If the mechanical complication and expense of Mr. Brennan's invention is not too great, it may be of extensive application in this field.

EXPERIMENTS ON PROPORTIONING CONCRETE TO SECURE MAXIMUM STRENGTH AND DENSITY.

In the Proceedings of the American Society of Civil Engineers for March, 1907, there appeared a paper on the "Laws of Proportioning Concrete" by Messrs William B. Fuller and Sanford E. Thompson, members of the Society, which is perhaps the most detailed and thorough study yet made of the principles underlying the correct distribution of the several materials that go to make up a concrete of the maximum strength. At a meeting of the Society held April 17, 1907, Mr. Thompson read the abstract of this paper, which follows:

Experiments made by one of the authors at Little Falls, N. J.,* in 1901, upon the density and transverse strength of concrete beams mixed in various proportions, indicated that the strength of concrete varies with the percentage of cement contained in a unit volume of the set concrete, and also with the density of the specimen. With the same percentage of cement in a given volume of concrete, the densest mixture, irrespective of the relative proportions of the sand and stone, was in general the strongest.

The Little Falls tests further indicated that for the materials used there was a certain mixture of sizes of grains of the aggregate which, with a given percentage, by weight, of cement to the total aggregate, gave the highest breaking strength. In practice, also, it was found that the concrete made with this mixture worked most smoothly in placing.

These results were brought to the attention of the Aqueduct Commission of the City of New York in 1903 by Mr. J. Waldo Smith, M. Am. Soc. C. E., then Chief Engineer for the Commission, and at his suggestion the Commission authorized a further study of these and related matters. The experiments were conducted at Jerome Park Reservoir, then under construction.

The tests were accordingly arranged with the view to ascertain the effect of different aggregates upon the density, strength and permeability of concrete, and particularly to determine the exact sizes of aggregate which, mixed together with a given proportion of cement, would form the best concrete. It also became necessary to study many related subjects, such as the physical characteristics of different cements, broken stone, broken stone screenings, gravel and sand, especially with reference to specific gravity, weight, voids, density, etc. Each material was tested by itself and when mixed in various proportions with others.

*For full report of Mr. Fuller's tests, see Taylor & Thompson's "Concrete, Plain and Reinforced," pp. 258 to 261.

The experiments were begun with a series of tests of the density of different mixtures of aggregates and cement, to study the laws of proportioning for maximum density with different materials, and these density experiments were followed by the manufacture of concrete beams for comparing the laws of strength with the laws of density, and determining the relation between these two qualities. As the compressive strength of concrete is a truer measure of its quality than the transverse strength—which in the case of concrete is really one form of tension test—two pieces of each beam after being broken in the beam machine were capped with neat cement so as to form prisms, and these were tested for compressive strength; a number of them were also tested for the compressive modulus of elasticity. A selected number of pieces of the broken beams were tested for permeability.

A number of conclusions have been drawn from the tests. Many of them introduce laws which the writers believe have not hitherto been recognized, and are opposed in certain cases to current ideas. Although based upon experiments with but two aggregates, these were so characteristic as to make the various comparative results of nearly general application.

These conclusions are stated at the beginning of the paper as printed in the Proceedings and to avoid repetition they will be given merely in connection with the diagrams illustrating them. For details reference may be made to the printed paper.

For the density, or volumetric tests, as they are termed in this paper, which were preliminary to the beam experiments, nearly 400 trial mixes of aggregates were made. These were composed of various sized particles,

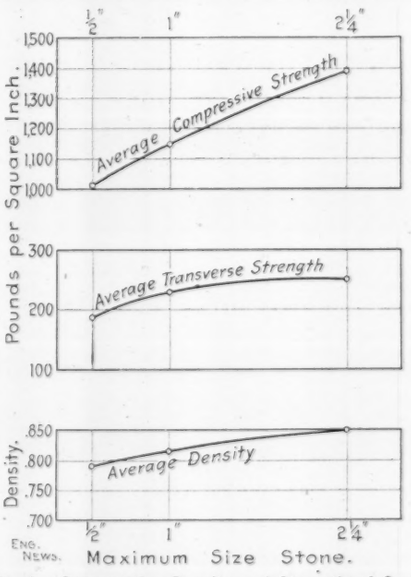


Fig. 1. Comparative Density and Strength of Concrete Containing Aggregates of Different Maximum Size.

following a logical plan, and containing first 10% of cement to the total weight of the dry materials and then other percentages of cement. The materials for each specimen were weighed separately and mixed with water to the same medium wet consistency, and the resulting volumes thus obtained from exactly the same total weight of dry materials (corrected for specific gravity) were compared.

In the first place, then, it was the aim to determine, for the various materials under consideration, artificial mixtures of aggregates graded in size by methods of mechanical analysis which would give concrete of maximum density. These ideal mixes having been determined, the concrete made from them could be compared, with respect to density, strength and permeability, with concrete made from simple mixtures of natural materials, and the best proportions to use upon active construction work could be fixed.

Two classes of materials were used for the aggregate: broken stone and screenings from the crushers at the reservoir, and Cow Bay gravel and sand dredged from the river.

Most of the experiments were made upon the same proportions; namely, 10%, by weight, of cement to the total dry materials, thus corresponding to proportions 1 : 9 by weight. In the earlier tests mechanical analysis mixtures were made to definite curves, such as parabolas and straight lines and curves intermediate between these, in order to select the curve giving the maximum density. In the later tests, in the winter of 1904-5, the methods were changed slightly, and the best results were obtained by making mixtures on trial curves without reference to their mathematical equations, and then, having found the best curves, equations were fitted to them, so that they could be more easily applied to different materials and more readily plotted. A description of these mechanical analysis curves is in a following paragraph.

In all the tests, instead of following the more usual plan of testing the aggregates separately, every experiment was performed with a mixture of the aggregate and the cement gaged with the water necessary to produce the proper consistency. The necessity may be questioned for using cement in the tests for density, which were really for the purpose of determining the best proportions of the various sizes of particles of the aggregate. Why would it not have been simpler to use only the dry aggregate with no cement or water, and thus more readily obtain the mixtures which would give the least volume with the same weight?

As a matter of fact, both theory and experiment prove that the mixtures of aggregate which give the greatest density when dry do not necessarily give the greatest density when mixed with the cement and water. The cement and water actually occupy space in the mass, as many of the voids are too small for the grains of cement to fit into them without expanding the volume, and the water surrounds the grains of fine sand and cement, and actually increases the bulk. As an illustration of this, the weight per cubic foot of very fine sand when loose, if weighed absolutely dry, is very nearly the same as the weight per cubic foot of a very coarse sand weighed dry. However, if the two sands are mixed with cement and water, the resulting mortar made with the fine sand will occupy a bulk perhaps 20% greater than the mortar of coarse sand, even when each of them is mixed with the cement in the same proportion by weight or by absolutely dry volume. The density of the mortar of fine sand will be correspondingly less than the mortar of coarse sand. Furthermore, the proportion of cement to sand affects the relative bulk and density of the two mortars, 1 : 1 mixtures giving different comparative results from 1 : 4 mortars.

For the density tests and the beams, the stone and screenings were separated in the laboratory by 21 sieves ranging in size from 3-in. openings to No. 200 mesh—the latter corresponding to an opening of 0.0027-in. By using different mixtures of the sizes separated by these sieves, it was possible to obtain an infinite variety of proportions.

The separation of the aggregates into these sizes was made with large sieves about 18 × 24-in. square, arranged in tiers on rocker frames. The aggregates when screened were labeled according to the size of sieve, which was passed and stored in bins and drawers ready for the volumetric tests.

MECHANICAL ANALYSIS CURVES.—Fig. 13 shows the mechanical analysis curves of the three sizes of stone and gravel and also the sand and screenings used in the experiments.

Mechanical analysis consists in separating the particles or grains of a sample of any material—such as broken stone, gravel, sand or cement—into the various sizes of which it is composed, so that the material may be represented by a curve, each ordinate of which is the percentage of the weight of the total sample which passes a sieve having holes of a diameter represented by the distance of this ordinate from the origin in the diagram. To illustrate with the 2¼-in. Jerome Park broken stone in the diagram—the curve indicates that all of the samples screened or 100% passed the 2.25-in. mesh screen; 78% passed the 1.50-in. mesh; 42% passed the 1-in. mesh, and so on.

The objects of mechanical analysis curves, as applied to concrete aggregates, are:

(1) To show graphically the sizes and relative sizes of the particles;

(2) To indicate what sized particles are needed to make the aggregate more nearly perfect and so enable the engineer to improve it by the addition or substitution of another material; and

(3) To afford means for determining the best proportions of different aggregates.

It is very easy when one has mastered the general principle involved to combine the analyses of two or more materials and form the curve of the mixture. In practice the curves are extremely useful for comparing different aggregates and combinations of aggregates for proportioning concrete. In the present series of studies, as a result of the volumetric tests, ideal mechanical analysis curves were determined for each material experimented upon, and equations of the curves which are given in the text were evolved. The best form of curve for all materials was found to be one resembling a parabola, or more accurately, a combination of an ellipse and a straight line.

As soon as the results of the density tests were available in 1905, a series of beams was made up according to definite plans, to compare the strength of concrete made with different materials and different proportions of the various diameters of particles. Cement and aggregate, graded by the curves of mechanical analysis which were found by the volumetric tests to produce concrete of maximum density for a given kind of material, were used as a basis for the tests, each specimen

being composed of 21 sizes of aggregate in the required proportions by weight.

The full report of the beam tests, both those made at an earlier date while the volumetric tests were in progress, which were somewhat unsatisfactory owing to the character of the cement, and also the later tests which form the principal subject of the paper, are presented in the Proceedings. It will be sufficient in this

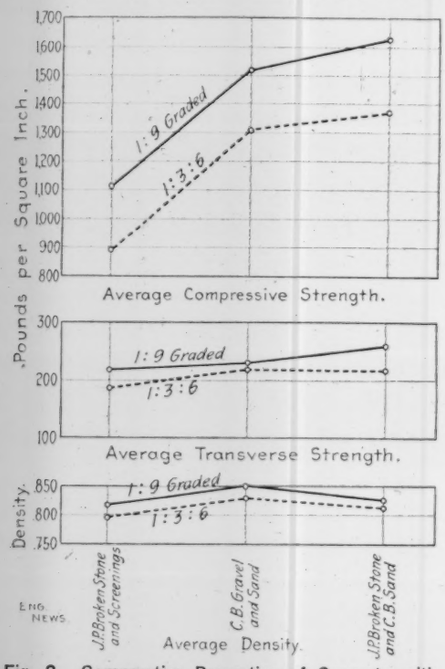


Fig. 2. Comparative Properties of Concrete with Graded Aggregates and With Proportions 1:3:6.

abstract to show by diagrams the more important results.

The diagram, Fig. 1, shows average curves of density, transverse strength and compressive strength of mixtures of cement and aggregates of different maximum size. From the tests the following conclusions were reached:

1. Stone of the largest maximum size makes the strongest concrete under both compression and transverse loading. A concrete in which the graded aggregate runs to 1-in. in maximum size will require for equal strength about one-sixth more cement, and with an aggregate running to ½-in. maximum size about one-third more cement than concrete with an aggregate in which the maximum size is 2¼ ins.

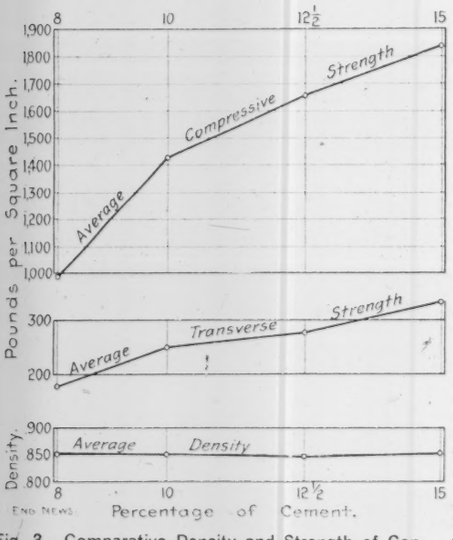


Fig. 3. Comparative Density and Strength of Concrete with Different Percentages of Cement.

2. The largest stone makes the densest concrete. Concrete made with graded stone having a maximum diameter of 2¼ ins. is noticeably denser than that with 1-in. stone, and this is denser than that with ½-in. stone.

The diagram, Fig. 2, gives the comparative density and strength of concrete made with Jerome Park broken stone and screenings, Cow Bay gravel and sand, and Jerome Park broken stone and Cow Bay sand. The proportions are 1:3:6 by weight, correction being made in the gravel for its different specific gravity. Although the density of the mixture of gravel and sand and cement is the greatest, the strength is less than the broken stone and sand concrete. The broken stone and screenings give the lowest density and also the lowest strength. The conclusions reached were:

3. Round material like gravel, under similar conditions, gives a denser concrete than broken stone.

4. Sand produces a denser concrete than screenings of similar sized grains.

5. A concrete with an angular coarse aggregate, such as broken stone, is stronger than one with a rounded aggregate, like gravel, although the rounded aggregate produces greater density—thus indicating a stronger adhesion of cement to broken stone than to gravel. However, if the sand is also angular, like screenings, but with its grains of the same sizes as the rounded sand, the concrete with both rounded coarse and fine aggregate is the stronger, probably because of its greater density.

Fig. 2 also illustrates the higher density and strength of the specially graded mixtures from which it was concluded:

6. Aggregates in which particles have been specially graded in sizes so as to give, when water and cement are added, an artificial mixture of greatest density, produce concrete of higher strength than mixtures of cement and natural materials in similar proportions. The average improvement in strength by artificial grading under the conditions of the tests was about 14%. Comparing the tests of strength of concrete having different percentages of cement, it is found that for similar strength the best artificially graded aggregate would require about 12% less cement than like mixtures of natural materials.

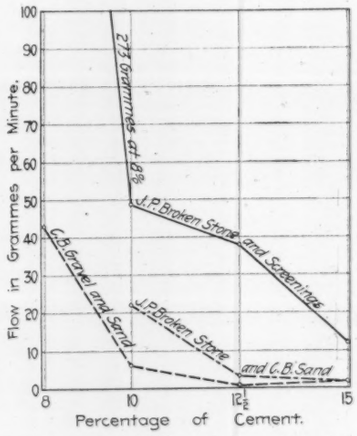


Fig. 4. Permeability of Concrete with Different Percentages of Cement.

(Specimens 6 × 6 × 17 ins.; age 140 days; pressure 80 lbs. per sq. in.)

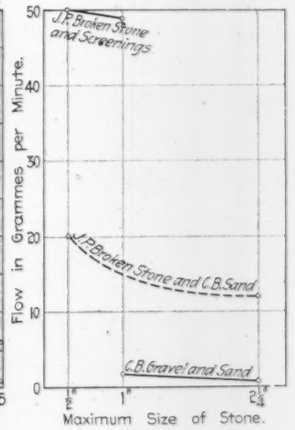

Flow in Grammes per Minute.
J.P.Broken Stone and Screenings
J.P.Broken Stone and C.B.Sand
C.B.Gravel and Sand
Maximum Size of Stone.

Fig. 5. Comparative Permeability of Concrete with Aggregates of Different Maximum Size.

(Specimens 6 × 6 × 17 ins.; age 140 days; pressure 80 lbs. per sq. in.)

Other conclusions which are referred to more in detail in the paper but of which no curves have been drawn also apply to the grading of the particles.

7. The strength and density of concrete is affected but slightly, if at all, by decreasing the quantity of the medium size stone of the aggregate and increasing the quantity of the coarsest stone. An excess of stone of medium size, on the other hand, appreciably decreases the density and strength of the concrete.

8. The strength and density of concrete is affected by the variation in the diameter of the particles of sand more than by variation in the diameters of the stone particles.

9. An excess of fine or of medium sand decreases the density and also the strength of the concrete, as will also a deficiency of fine grains of sand in a lean concrete.

10. The substitution of cement for fine sand does not affect the density of the mixture, but increases the strength, although in a slightly smaller ratio than the increase in the ratio of cement.

Fig. 3 especially illustrates this last conclusion, showing the uniform density of mixtures with increasing percentages of cement and consequently increasing strength.

11. It follows from the foregoing conclusions that the correct proportioning of concrete for strength consists in finding, with any percentage of cement, a concrete mixture of maximum density, and increasing or decreasing the cement by substituting it for the fine particles in the sand or vice versa.*

12. In ordinary proportioning with a given sand and stone and a given percentage of cement, the densest and strongest mixture is attained when the volume of the mixture of sand, cement and water is so small as just to fill the voids in the stone. In other words, in practical construction, use as small a proportion of sand and as large a proportion of stone as is possible without producing visible voids in the concrete.

13. The best mixture of cement and aggregate has a mechanical analysis curve resembling a parabola, which is a combination of a curve approaching an ellipse for the sand portion, and a tangent straight line for the stone portion. The ellipse runs to a diameter of one-tenth of the diameter of the maximum size of stone, and the stone from this point is uniformly graded.

14. The ideal mechanical analysis curve, i. e., the best curve, is slightly different for different materials. Cow Bay sand and gravel, for example, pack closer than Jerome Park stone and screenings, and therefore require less of the size of grain which the writers designate as sand.

15. The form of the best analysis curve for any given material is nearly the same for all sizes of stone, that is, the curve for ½-in., 1-in. and 2¼-in. maximum stone may be described by an equation with the maximum diameter as the only variable. In other words, suppose a diagram in which the left ordinate is zero, and the extreme right ordinate corresponds to 1-in. stone, with the best curve for this stone drawn upon it. If, now, on this diagram the vertical scale remains the same, but the horizontal scale is increased two times, so that the diameter of ½-in. stone corresponds to the extreme right-hand ordinate, the best curve for the ½-in. stone will be very nearly the one already drawn for the 1-in. stone. The chief difference between the two is that the larger size of stone requires a slightly higher curve in the fine sand portion.

It follows from this last conclusion that, from a scientific standpoint, the term "sand" is a relative one. With 2¼-in. stone, the best sand would range in size from almost 0 to 0.22-in. in diameter, while the best sand for ½-in. stone would range in size from nearly 0 to 0.05-in. in diameter.

Permeability tests were made on a number of the specimens by coating pieces of beams broken in the testing machine with neat cement and forcing water through a length of about 18-in. Several interesting comparisons were obtained from the permeability tests, although a number of them, especially those with the Jerome Park stone and screenings, were somewhat erratic because of the difficulty of making perfect specimens with this angular material.

The diagram, Fig. 4, shows the quantity of water passing through specimens containing different percentages of cement. The conclusion is reached that:

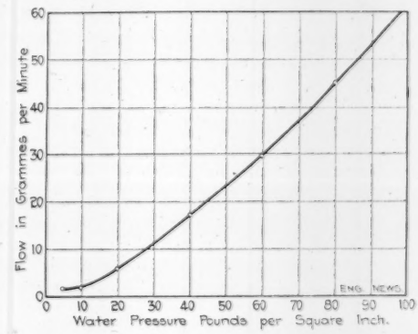


Fig. 6. Increase of Permeability of Concrete with Pressure.

(Proportions 1 : 3 : 6, Jerome Park broken stone and screenings. Test piece 6 × 6 × 17 ins.; age 120 days.)

17. The permeability or flow of water through concrete is less as the percentage of cement is increased, and in very much larger inverse ratio.

The effect of different maximum sizes of the stone upon the permeability is shown in Fig. 5. The conclusion is reached that:

18. The permeability is less as the maximum size of the stone is greater. Concrete with maximum size stone of 2¼-in. diameter is, in general, less permeable than that with 1-in. maximum diameter stone, and this is less permeable than that with ½-in. stone.

*This very important law requires further tests for confirmation outside of the limits of the present tests.

The conclusion is reached from the same diagram that:

19. Concrete of cement, sand and gravel is less permeable than concrete of cement, screenings and broken stone; that is, for equal permeability, a slightly smaller quantity of cement is required with rounded aggregates like gravel than with sharp aggregates like broken stone.

20. Concrete of mixed broken stone, sand and cement is more permeable than similar concrete of broken stone,

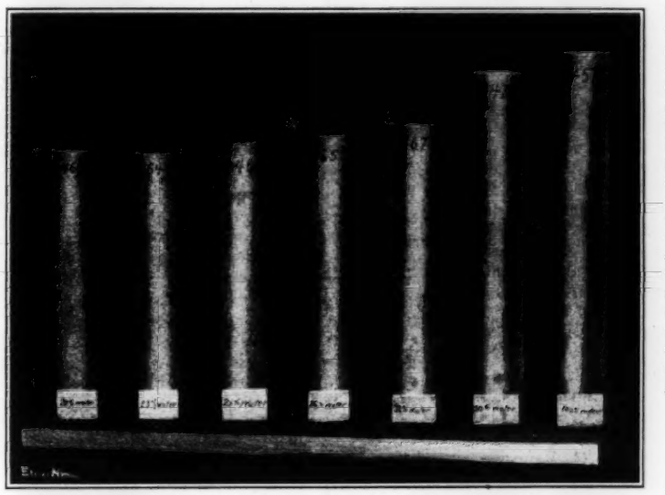


FIG. 7. VARIATION IN VOLUME OF PASTE PRODUCED BY MIXING THE SAME WEIGHT OF CEMENT WITH DIFFERENT PERCENTAGES OF WATER.

screenings and cement; that is, for water-tightness, less cement is required with rounded sand and gravel than with broken stone and screenings.

The next curve, Fig. 6, shows the increase of flow with pressure. Other tests not shown in the diagram illustrate the effect of age and thickness of concrete, so that the conclusion is reached:

21. The permeability decreases materially with age; increases nearly uniformly with the increase in pressure; and increases as the thickness of the concrete decreases, but in a much larger inverse ratio.

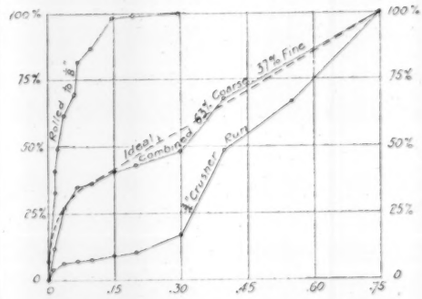


Fig. 8. Proportions of Concrete, Fuller's Method.
(Aggregate: Shawangunk grit, ¾-in. crusher run and rolled to ⅛-in.)

During the progress of the experiments at Jerome Park frequent tests were made of the density of the cement which was being used and also of the densities of various mortars. For this purpose the volumetric

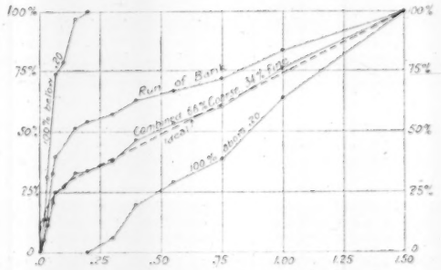


Fig. 9. Proportions of Concrete, Fuller's Method.
(Aggregate: Plattekill No. 1, screened to two sizes.)

cylinder apparatus described was used; tests were also made on a smaller scale, with a 200 c. c. graduate for the mold.

Fig. 7 illustrates the variation in volume of paste produced from the same weight of the same cement with different percentages of water. When sand is mixed with the cement there is much less variation in the volumes of the mortars due to different percentages of water than in neat pastes, but the variation is generally very appreciable, although less with coarse than with fine sands.

The resulting volumes of different concretes, of the same materials and proportions but with varying percentages of water, are nearly constant, provided sufficient water is added to permit thorough compacting. When an excess of water is used, it is nearly all expelled as the solid materials settle by gravity. There is, however, a slight variation even in concrete. A dry mixture, provided sufficient water is added to rise to the top on hard ramming, can be compacted somewhat more than a concrete of medium consistency, while a very wet concrete is apt to occupy a very slightly larger volume, and hence be less compact than a medium concrete. In most cases, the difference between the medium and very wet mixtures is only noticeable by extremely accurate measurements.

APPLICATION OF MECHANICAL ANALYSIS CURVES TO SPECIAL WORK.

As an example of the possibilities in the use of the method of determining the proper graduations of aggregate by means of a reduction to an ideal mechanical analysis curve, Mr. J. L. Davis, Assoc. M. Am. Soc. C. E., submitted, in the discussion to the above paper, several analyses which he had made. Mr. Davis is connected with the Board of Additional Water Supply of the City of New York, and has had charge of a series of tests on various aggregates which are to be used in concrete construction. The particular examples here shown illustrate well the application of the methods of proportioning concrete given in Messrs. Fuller and Thompson's papers to a few other aggregates than the two used in the experiments on which the conclusions given were based. The abstract of Mr. Davis's discussion follows:

What is herein presented contains nothing original as to method. It is simply the application of methods of the preceding paper to a few aggregates as they have been found, shown by means of curves. It is thought best not to go into the mathematics of combining the curves. The methods by which this is done are not difficult and are very fully explained in the well known book, "Concrete; Plain and Reinforced," by Messrs. Taylor and Thompson, in the chapter on proportioning concrete written by Mr. Fuller. Fig. 8 shows a study of a crushed rock, the mechanical analysis being made and plotted in the manner previously described. The Shawangunk grit is a quartzite. The lower curve shows the analysis of the material as it came from the crusher, in size from ¾-in. down. The upper curve shows the same material run through rolls set ⅛-in. apart. The ideal curve, as figured by Messrs. Fuller and Thompson, is shown broken. This curve was plotted by using the constants given for Jerome Park crushed stone, that stone being taken as representative of crushed rock in general, so far as the constants are concerned. The combined curve shows the result of combining the two sizes of materials in the proportions of 63% coarse and 37% fine. The resulting curve conforms closely to the ideal down to the 0.4-in. diameter stone. From there down to a 0.15-in. diameter there is a deficiency. This, of course, could be remedied by combining in different proportions, resulting in the combined curve coming higher, but one of the conclusions of the paper is that a deficiency of the medium sized stone will not result in a loss of strength of concrete while an excess of this sized stone will give such a loss. Therefore the proportions had better not be changed. The combined curve also shows deficiency in the quantity of fine sand, but this will be made up by the addition of the cement as the ideal curve includes the cement, and with the cement added we should have a new or corrected combined curve for the sand portion which would approach the ideal. This study is a very ordinary case. Fig. 9 shows a gravel. The run of the bank is plotted and the lower and upper curves show the result of screening this material to two sizes, that which is retained on a sieve of 0.2-in. mesh or clear opening and that which passes this sieve. The ideal curve was plotted with the constants given for Cow Bay gravel. The ideal curve shows by the length of the ordinate at 0.2 in. diameter that 66% of the ideal mix should be coarser than this size. The combined curve shows the result of taking this percentage of the coarse material and 34% of fine, giving a very close approach to the ideal mix. There is a deficiency of fine sand, but as in the case of the Shawangunk grit this would be made up by the cement.

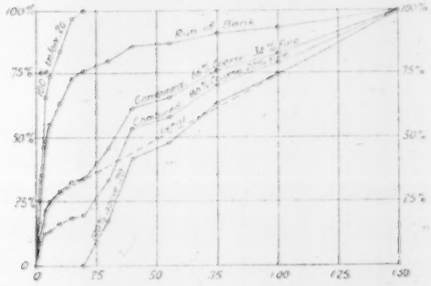


Fig. 11. Proportions of Concrete, Fuller's Method.
(Aggregate: Cortland No. 6, screened to two sizes.)

Fig. 10 shows a crushed limestone available in the New York markets. The lower curve shows the product sold as 2¼ in. It actually ranges from 2 in. to ¾-in. Such stone is often used with screenings as a substitute for sand. The upper curve shows such a material produced by a crusher with jaws set to maximum opening of ¼ in. The two combined curves show how, by a little scientific study, improvement may be made in the light of these experiments over the usual rule of thumb methods of mixing. Suppose a concrete is wanted in proportions of 1 cement to 8 aggregate. A common proportion in ordinary work would be 1:2½:5½. This is equivalent in this case to 60% coarse and 40% fine aggregate. The plot shows a deficiency in all sizes below about 1¼ in. diameter. An improvement is shown by the upper combined curve in proportions of 49% coarse and 51% fine aggregate, and this case involves no extra expense for labor, but might increase the cost somewhat by the use of the increased proportion of fine material, as it is more expensive to crush to this fine size. Fig. 11 shows a gravel from the town of Cortland. It was selected not because it particularly well illustrates the application of this method of proportioning, but because it was evidently one of the best gravels to be found in the vicinity where it occurred. We often see concrete made by mixing a certain proportion of cement with gravel as it comes from the bank. Comparison of the curve of the run of the bank with the ideal shows how far from proper results such a course would give in this case. The upper and lower curves show the analyses of this material screened to two sizes, as in a preceding case. The ideal curve shows by the length of the ordinate at 0.2-in. diameter that 66% of the mix should be coarser than this size. The upper combined curve shows the result. This gives almost ideal results for the sound portion, but altogether too large proportions, passing various medium sized screens.

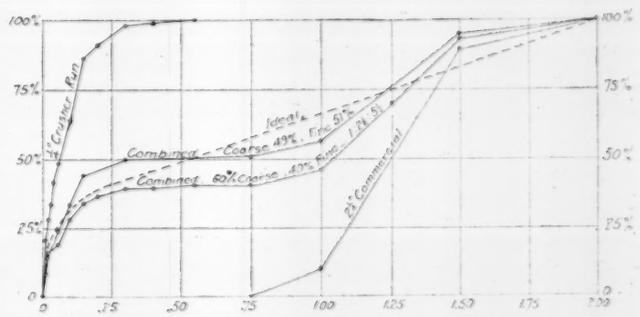


FIG. 10. PROPORTIONS OF CONCRETE, FULLER'S METHOD.
(Aggregate: Crushed limestone, 2¼-in. commercial and ¼-in. crusher run.)

The lower combined curve shows the result of attempting to remedy this by using a larger proportion of the coarse material—the stone portion of the mix is improved, but the sand portion becomes totally unfit. This demon-

strates that this material screened to these two particular sizes cannot be combined in ideal proportions. Inspection of the curves shows the material retained above 0.2-in. diameter conforms closely to the ideal down to 0.4-in. diameter and that the trouble with the combined curves is between 0.2 and 0.4-in. diameter. This suggests screening the material into three instead of two sizes. The result is shown on Fig. 12. On this slide the run of the bank, the ideal curve and the material below 0.2-in. size are again plotted as on Fig. 4. The

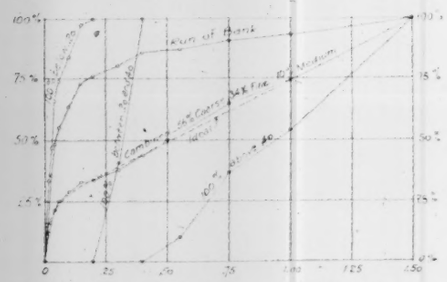


Fig. 12. Proportions of Concrete, Fuller's Method.
(Aggregate: Cortland No. 6, screened to three sizes.)

coarse material has been separated into two sizes, from 0.4-in. up and from 0.2 to 0.4-in. The combined curve shows the result of combining the three sizes in proportions of 56% coarse, 34% fine and 10% medium. The result is a close conformation to the ideal curve, and it may be safely stated the resulting concrete would be strong and economical.

It would not be at all impracticable to use these proportions as it would only be necessary to interpose another screen of about ⅝-in. mesh when screening out the sand from the run of the bank.

By the methods of this paper we have means of making laboratory comparisons of different aggregates and studying various mixtures. The methods are not at all in conflict with the more common ones of determining the proportions of voids in the aggregate, but are in reality more accurate and scientific means of accomplishing the same result.

AN ELECTRIC MAST HOIST of considerable merit as to compactness and facility of operation has been developed by the Lidgerwood Mfg. Co., of New York, and so far supplied only to the contractors who are building the foundations for the Hudson River Terminal at Fulton, Church and Cortlandt Streets, New York, and for the City Investing Building opposite. The construction of the base platform does away with the large "bull-wheel," and is such that the operator, standing upon it, has his load always in plain view.

The hoist has a nominal capacity of 4,000 lbs. at a speed of 130 ft. per min. It has two friction drums of the regular style, each 12 ins. in diameter and of 19¾ ins. face, with band brakes, ratchets and pawls; one drum operates the topping lift, and the other the hoisting line. The swinging gear is mounted on the side of the mast opposite the drums; through bevel gearing and a vertical shaft it drives a pinion which meshes with internal teeth on a ring bolted to the foundation. The motor is a 20-HP. General Electric series wound, using direct current at 250 volts; the controller is of the railroad type, and special resistances are mounted in the bed plate of the hoist. The brakes are operated by foot levers, the friction drums by hand levers at the operator's right in a rack, and the swinging gear by a horizontal lever attached to the mast.

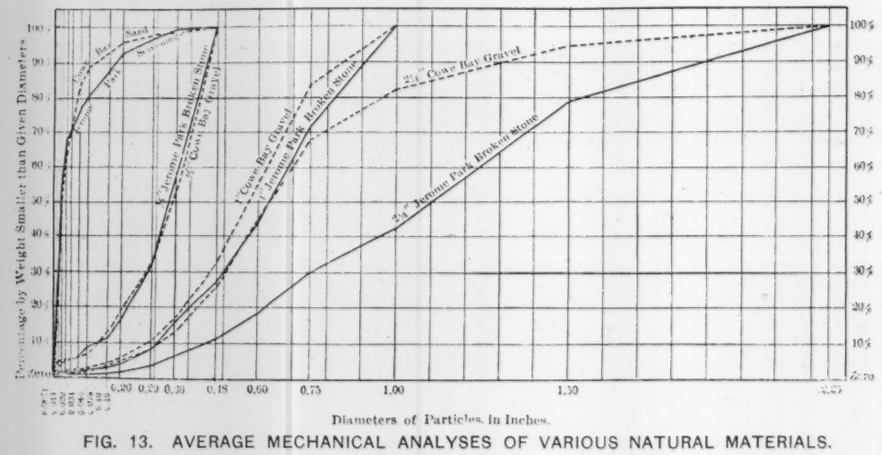


FIG. 13. AVERAGE MECHANICAL ANALYSES OF VARIOUS NATURAL MATERIALS.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION CONVENTION AT PHILADELPHIA.

With business headquarters at the Second Regiment Armory, at Broad St. and Susquehanna Ave., and social headquarters at the Bellevue-Stratford Hotel, the tenth annual convention of the American Foundrymen's Association opened at Philadelphia on Monday, May 20. Allied associations which took a prominent part and interest were the Foundry Supply Association, the Associated Foundry Foremen and the Philadelphia Foundrymen's Association—the last named being the one providing the entertainment features of the convention. At the convention was also a representative gathering of brass founders, and out of these crystallized the American Brass Foundrymen's Association, later in the week.

The opening day of the convention was mainly occupied in the registration of delegates. At 10 A. M. the exhibit of the Foundry Supply Association was formally opened at the armory, to remain a leading attraction throughout the convention; the broad floor of the armory accommodated about 35 exhibits of various kinds, and a large tent pitched at the south end of the armory, provided for an overflow of half that many more. A great variety of molding machines, large and small, was shown; perhaps as notable an example as any of these was the exhibit of the "Universal System" of machine molding by Ph. Bonvillain and E. Ronceray, of Paris, France, under the direction of M. Ronceray—notable because brought so far to show in competition with American systems, among which, be it also said, it made a most excellent showing. Representative American firms maintained exhibits of blowers, conveyors, cranes and hoists, gas engines, furnaces and crucibles, sands and graphites, cars and track systems, etc.—in short, every sort of appliance of interest to the foundry industries.

At 2:30 P. M. the Foundry Supply Association held an executive session for the appointment of committees, and at 8:00 P. M. the Associated Foundry Foremen held their annual meeting at the Manufacturers' Club, 1409 Walnut St., and elected its officers for the coming year. These were: President, James B. Webb, Foundry Department of Lake Shore & Michigan Southern Ry., Elkhart, Ind.; First Vice-President, W. S. McQuillin, Allegheny Foundry Co., Warren, Pa.; Second Vice President, W. O. Steele, Bateman Mfg. Co., Grenlock, N. J.; Secretary-Treasurer, F. C. Everitt, J. L. Mott Co., Trenton, N. J.

On Tuesday morning, May 21, the real activities of the convention began. The armory was open at 9:30, the supply exhibits and demonstrations continuing all day. At 10 o'clock the opening session of the American Foundrymen's Association was held in the Assembly Room of the armory. Hon. J. E. Reyburn, Mayor of Philadelphia, delivered an address of welcome, followed by Mr. Thomas Devlin, President of the Philadelphia Foundrymen's Association, Dr. Elmer E. Brown, Chairman of the Entertainment Committee, and Mr. W. A. Perrine, President of the Philadelphia Foundry Foremen's Association. Responses were made by Messrs. Wm. H. McFadden, President of the American Foundrymen's Association, S. T. Johnson, President of the Foundry Supply Association, and Hugh T. McPhee, President of the Associated Foundry Foremen. After the Presidential address by Mr. McFadden, and the reports of committees, the following papers were read: "Sound, Clean Castings," David Spence, Franklin, Mass.; "The Gray Iron Foundry as a Business Venture," Thos. D. West, Sharpsville, Pa.; "The Malleable Foundry as a Business Venture," Dr. Richard Moldenke, Secretary of the A. F. A.; "Manganese in Cast Iron," Herbert E. Field, Pittsburg.

The afternoon was given to presentation of other papers, those read being "Cast Thread Fittings"—illustrated by samples—Henry B. Cutter, Seneca Falls, N. Y.; "Small Points in the Core Room, which are Not Considered," Henry M. Lane, Cleveland; "The Evolution of the Foundry Business," Edw. B. Gilmour, Elizabethtown, Pa. Active discussion was made of all of these papers by members of the various associations.

Tuesday evening was devoted to social activity, the event being a vaudeville entertainment and smoker given to the visitors by the Philadelphia Foundrymen's Association, at Lu Lu Temple (Mystic Shrine), Broad and Spring Garden Sts. Both halves of this entertainment were most creditable to the local organization; Dr. Moldenke was presented, as a mark of appreciation of his services to the National Association, with a silver punch bowl and a purse containing $1,200 in gold.

On Wednesday morning, May 22, a meeting was held for the purpose of organizing an association among brass foundrymen and the allied industries—bronze workers, polishers, etc. Mr. Chas. J. Caley, of New Britain, Conn., presided and delivered the opening address. A nominating committee composed of the following men was appointed: Palmer Langdon, Publisher of "The Metal Industry," New York; Chas. H. Proctor, of F. N. Lovell & Co., Arlington, N. J.; W. R. Webster, of the Bridgeport Brass Co.; Aug. A. Miller, of the "Iron Age;" H. O. Evans, Secretary J. W. Paxson Co., Philadelphia; Jas. B. Webb, Elkhart, Ind., and Wm. Corse, of the Detroit Lubricator Co. A committee on by-laws was also appointed—Dr. Moldenke, Palmer Langdon and W. M. Corse. After the report of the nominating committee on the following day, officers were elected; the President, Chas. J. Caley; Secretary, Andrew M. Fairlie, of the Tennessee Copper Co., Copper Hill, Tenn.; Treasurer, J. H. Sheeler, of the Sheeler-Hemsher Co., Philadelphia.

Papers were read at this session on "Science Applied to the Brass Industry," Andrew M. Fairlie; "Electro-Deposition of Brass," Chas. H. Proctor. At the afternoon session the time was entirely given to papers and technical addresses. Mr. W. W. McCarter, Superintendent of the Foundry Department of the Glover Locomotive & Machine Works, Marietta, Ga., told of "The only foundry trade school ever operated on a commercial basis;" "Sandless Castings" (in chilled molds), written by John H. Shaw, of Sargent & Co., New Haven, Conn., was read in his absence by Mr. V. F. Lamb. Prof. T. R. Coggeshall, Superintendent of the Mechanical Schools of Girard College, Philadelphia, was in attendance with 19 of his foundry students; he gave a brief talk on the work of the college in that direction, saying that out of 1,600 students at the college, 98 were enrolled in the mechanical classes. Prof. Wm. C. Stimson, of Pratt Institute, Brooklyn, gave a description, illustrated by lantern slides, of the foundry work at the institute; Mr. E. A. Johnson, of the Winona Trade School, at Indianapolis, Ind., gave a similarly illustrated description of the work there. "Industrial Betterment" was the topic of an address by Mr. H. J. F. Porter, of New York, in which he discussed and illustrated with slides various advances made in this country by large employers of labor; he showed views of workmen's homes, libraries and club rooms at factories, bowling alleys, infirmaries, music rooms, gymnasiums, etc., as means for building up loyalty and higher moral life among

workmen; a portion of his address was devoted to sanitation of plants, and prevention of disease among operators on abrasive machines, etc. The concluding paper of the session was by Monsieur E. Ronceray, of Paris, illustrating with slides the features and operation of his "Universal" molding machines. This paper was novel in that the several sizes of machines were shown in operation by means of the cinematograph. M. Ronceray also exploited a new mode of preparing molding sand by coating the grains of sharp, silicous sand with clay by rubbing—a machine being shown for that purpose—thereby coating each grain with the clay and giving the mass cohesive properties not possessed by the pure sands.

Wednesday evening was set apart for special demonstrations of apparatus in the supply exhibit.

On Thursday, May 23, at 10:00 a. m., the American Brass Foundrymen's Association held its closing session; and at 11 o'clock the closing session of the American Foundrymen's Association was called.

The latter association elected at this session its officers for the coming year. These were as follows: President, Mr. Stanley G. Flagg, Jr., of Stanley G. Flagg & Co., Philadelphia; Vice Presidents, Messrs. Chas. J. Coley, John W. Burr, Herbert E. Field, J. H. Whiting, A. K. Beckwith, T. W. Sheriffs, J. P. Golden, and L. L. Anthes; Secretary and Treasurer, Dr. Richard Moldenke. The only paper read at this session was "The Art of Galvanizing," by Alfred Sang, of Pittsburg.

The afternoon of May 23 was devoted to a river trip by boat, including an inspection of the Otto-Hoffman by-product coke plant, and ending with a shad dinner at Washington Park on the Delaware. Another excursion took numbers of the delegates to Atlantic City for an outing. Both excursions were tendered by the Philadelphia association.

Friday, May 24, the last day of the convention, was scheduled for a number of trips to local plants of interest. Among those visited were the plants of the Link Belt Co.; the Niles-Bement Pond Co., foundry and machine shops; the Enterprise Mfg. Co.; the Camden Iron Works; the J. W. Paxson Co.; and the Engineering Laboratory of the University of Pennsylvania.

At 10:00 a. m. the Foundry Supply Association held its closing session and elected the following officers for the coming year: President, Mr. E. H. Mumford, of the Mumford Mfg. Co., Philadelphia; Vice Presidents, Mr. W. P. Shepard, of Rogers, Brown & Co., Buffalo; Mr. W. S. Quigley, of the Rockwell Engineering Co., New York; Mr. H. E. Atwater, of the Osborn Mfg. Co., Cleveland, and Mr. Wm. Chambers, of the Garden City Sand Co., Chicago; Secretary, Mr. Henry M. Lane, Consulting Engineer, Cleveland; Treasurer, Mr. J. S. McCormick, of the J. S. McCormick Co., Pittsburg. In view of the increased scope of the association's work and consequent heavier demand on his time, the salary of the secretary was increased by unanimous vote from $500 to $1,000 per year.

The attendance at this convention was the largest in the history of the association; including guests—relatives of the delegates and press representatives—the total registration was 1,390. Delegates came from a wide radius—Kansas to the West, Georgia to the South, and Quebec, Canada, to the North; a considerable party accompanied Mr. Ronceray from Paris, France.

Buffalo and Toronto will probably be the scene of next year's convention.

STEEL FREIGHT CARS are being extensively used in South America, and the Brush Electrical Engineering Co., of Loughborough, England, has recently built a number of steel gondolas and box cars for the Buenos Ayres & Pacific Ry., 5 ft. 6 ins. gage. They are of plates and standard shapes, and have the Sheffield-Twinberrow type of diamond truck, in which no spring plank is used. The box cars are 34 ft. long over end sills, and have three roof manholes for loading grain; they are of 44 tons and 3,000 cu. ft. capacity, with a light weight of 15 tons. The 40-ton gondolas weigh 13½ tons. They are 37 ft. 6 ins. long over the buffers, 9 ft. 7 ins. wide, and have the trucks spaced 23 ft. c. to c. The trucks have 37½-in. wheels and 5 ft. 9 ins. wheel base.

THE ELEVENTH ANNUAL MEETING OF THE NATIONAL FIRE PROTECTION ASSOCIATION.

The annual convention of this Association, made up of those engaged in the work of fire prevention, was held at the Engineering Societies Building, New York City, on May 22, 23, 24. The work of the Association is done mainly through committees on special subjects. We have below very briefly outlined in the order of presentation the more important reports and the individual papers presented. Several papers not mentioned here were presented by title only. A few reports dealing with subjects of interest especially to insurance men we have omitted.

SPECIAL HAZARDS AND FIRE RECORD. COMMITTEE REPORT.—This committee has attempted to collect and tabulate all available information about fires in plants for the manufacture of inflammable products.

The operation and weaknesses in present systems of fire-control were shown by the following tables:

FIRES IN MANUFACTURING PLANTS.

How Discovered.	Times Reported. 1907.	Ten Years. 1897-1907.
Employee	563	3,097
Watchman	153	821
Sprinkler Alarm	94	953
Outsider	42	328
Thermostats	29	275
Automatic pump	0	3

FAILURE OF ALARM SERVICE, 1907.

	Discovered Fire.	Failed.	Per Cent. Failed.
Watchman	153	45	23
Thermostats	55	16	22
Sprinkler Alarm	375	27	7

The effectiveness of the sprinkler systems are shown by figures presented below.

EFFECT OF SPRINKLERS.

	Times Reported. 1907.	Ten Years. 1897-1907.	Per cent. of No. with Data Given. 1907.	Ten Years. 1897-1907.
Practically or entirely extinguished fire	594	3,563	66.96	67.06
Held fire in check	240	1,419	27.06	26.70
Total successful	834	4,982	93.92	93.76
Unsatisfactory	53	331	5.98	6.23
	887	5,313		

NITRO-CELLULOSE PRODUCTS. COMMITTEE REPORT.—This subject was presented by a sub-committee of the one on Special Hazards. The term "nitro-cellulose" was used to designate certain substances, rather than the word "celluloid," which refers to only one of a class. There had been so much controversy over the inflammability and explosiveness of these products and their uses are so widespread and so diversified that this sub-committee was appointed to search for the truth.

The major portion of the report outlines the process of manufacture, always pointing out the fire risks. The properties of cotton fiber, nitric and sulphuric acids, camphor, alcohols, acetone, ether and naphtha were shown to greatly increase chances for fire, and to require special handling and storing.

It is well known that those of the series of nitro-cellulose products, produced by the lesser action of nitric acid on cotton, have the same general nature as the intended explosive varieties, and differ chiefly in their explosive tendencies. This investigation has shown that these products intended as a basis for manufactured articles, will explode with great violence, under certain conditions not well understood. The evidence indicated that dry soluble cotton could not be exploded except by friction or a spark. The explosion of one mass would not necessarily cause the explosion of nearby amounts, through concussion. It was stated that the compounds of camphor and nitro-cellulose were liable to explode when slowly heated in a confined space at a temperature lower than the ignition point. Explosive fumes are liable to be given off by these compounds in burning.

DEVICES AND MATERIALS. COMMITTEE REPORT.—This committee, acting with the engineers of the Underwriters' Laboratories., Inc., tests devices and fittings such as extinguishers, wired glass fittings, fire doors and hardware, watchmen's registers, etc, etc. If the devices are effective and a time to time inspection of the process of manufacture shows the output equal in quality to samples, labels are issued stating that the device was "constructed under the supervision of the Underwriters' Laboratories," and bearing a serial number. By such supervision and labeling a ready means has been provided whereby approved appliances can readily be distinguished in use. The small cost of such service was emphasized, and shown to be less than 1% of the average selling price of the labeled goods.

On account of the volume of work thrown onto the committee and the limited equipment of the laboratories, structural methods and materials were not touched. It is planned to start such work during 1907.

OPEN SPRINKLER SYSTEMS. COMMITTEE REPORT.—The work of this sub-committee during the year was the investigation of standard systems of open sprinklers as installed, to determine what changes were needed. Through the courtesy of the Manufacturer's Automatic Sprinkler Co., of New York, and of the Bush Terminal Co., a standard system of six lines of twelve open sprinklers each was installed on the side of a brick warehouse in Brooklyn and considerable experimental work done with it. It was found that the discharge from the middle and lower lines was too great in comparison with that from the two upper lines. To study the equalization of discharge an experimental system was installed, and from the results of tests with this outfit there was advocated a reduction of the size of orifices in the middle lines of sprinkler systems and a reduction in size of pipes for the lower lines. As in 1908 all sprinkler standards come up for revision, no action was taken on this new arrangement. Additional experimental work will be carried on.

FIRE PROTECTING COVERINGS FOR WINDOWS AND DOORS. COMMITTEE REPORT.—Circulars asking for specific information on desired amendments to present standards were sent out during the year. From such information received, it seemed that the present code was satisfactory. A few minor changes in the requirements for tin-clad fire doors were adopted.

STANDARD HOSE COUPLINGS AND HYDRANT FITTINGS FOR PUBLIC FIRE SERVICE. COMMITTEE REPORT.—A wider presentation of the merits of the "National Standard" for these fittings has been attempted. As a result 13 authoritative bodies have approved and adopted it. Their influence is so wide that a universal adoption of the standard is promised.

THE SEASON HOTEL.—A paper by Mr. H. L. Hiscox, Boston, Mass. The paper was general in character and took up such considerations as season, location, attractions, fire risks and protection, fire statistics for hotels, best standards of construction. It was attempted to collect and unify all the work along these lines, as presented in previous engineering papers and journals.

AUTOMOBILE GARAGES. COMMITTEE REPORT.—Automobiles and garages were defined in this report. The building and storage requirements, from the insurance standpoint, were outlined.

THE COTTON BALE AS A SOURCE OF LOSS BY FIRE.—Paper by Mr. Benj. Richards, Boston, Mass. This paper was a review of the very deplorable conditions causing the very heavy fire losses in American baled cotton.

CAR HOUSES. COMMITTEE REPORT.—The committee reported several recommendations concerning fire walls which, while good from a fire protection standpoint, were at variance with some desired designs of car stations. On this account the recommendations will pass to a conference with the American Street and Interurban Railway Association.

TIN AND TERNE PLATE.—Paper by A. P. Straddling, Philadelphia, Pa. In this paper the development of the tin plate industry was briefly traced. The original "charcoal" and "coke" iron plates were described, as well as the use of such terms to-day to express the character and thickness of the tin coating. The use of Bessemer and open-hearth steels was taken up and the more favorable qualities of the latter discussed. The "palm oil" process of coating was outlined generally with reasons for its

claimed superiority over rolled coatings laid on by acid fluxes.

ROOFS AND ROOFING. COMMITTEE REPORT.—About thirty pages of this report embodied requirements for fireproof, semi-fireproof and inflammable construction. It was contended that this covered waterproofing on fireproof buildings, which was claimed to be outside the objects of the association, since they affected fire protection only in the very indirect way of preventing deterioration by leaky roofs. The committee was continued another year for further study and tests.

FIREPROOF CONSTRUCTION. COMMITTEE REPORT.—The building code of the National Board of Fire Underwriters was endorsed except in some points, which were not accepted by the committee. Mr. Alfred Stone, Providence, R. I., a member of this committee, presented charts and curves showing that the code requirements for walls in fireproof construction were unreasonable for strength requirements and not at all uniform. He maintained that a 12-in. wall was of sufficient thickness on the upper two stories under the same conditions that the Underwriters' Code required 16 ins. While that code demanded a 16-in. wall for the upper floors of a 10-story building, yet it permitted 12 ins. on the upper parts of a 5-story structure.

On account of such differences it was voted that these requirements should be taken into a conference with the Fire Underwriters' Association to harmonize differences and to evolve uniform requirements.

CEMENT FOR BUILDING CONSTRUCTION. COMMITTEE REPORT.—The name of this committee seemed to be a misnomer, as they did not deal with the cement, except to require a uniform good quality. Hollow concrete building blocks have been and are being tested in the Chicago laboratories of the association, in connection with the government laboratories in St. Louis. The committee was not prepared to submit a detailed standard for the manufacture and use of hollow concrete blocks, but as the material is coming into such an extended use some grade for it was thought necessary.

It was the opinion of the committee that a block wall should be rated as better than a frame wall, simply because it was incombustible. It was held, however, as inferior to a brick wall on account of greater liability of fracture from unequal expansion and prevalent poor workmanship. The general recommendations of the committee were adopted. It was continued another year for experimental work under the name "Committee on Concrete and Reinforced Concrete Construction."

FACTORY STANDARDS. COMMITTEE REPORT.—This committee presented standardized requirements for general "mill construction" and factories for cotton, nitro-cellulose and rice products. These requirements found some opposition as being too ideal and more expensive than was demanded. The standard of "mill construction" was referred to the committee on Uniform Requirements. The proposed standard for cotton mills was referred back to the original committee, and the remainder ordered printed in the proceedings as information for members.

MATCHES. COMMITTEE REPORT.—Experiments have been made to determine the relative safety of the matches on the market. It was shown that matches in common use were confined to four types, known as parlor, sulphur, double dip and safety. All others are more or less novelties and form such a small part of the output that they have not been considered.

It was stated that the parlor match head will explode with violence, often throwing portions of the glowing head into combustibles. The sulphur match contains no chlorate of potash and will not explode, but it will ignite by simple friction or when stepped on. While somewhat preferable to the parlor variety, it is not considered good from the fire protection view. The double dip match, a recent invention, has a combination head of opposite characteristics. The splint is first dipped into a composition similar to that for a safety match. Later it receives a second dip similar to the sulphur match. While the match was not approved, three redeeming features were mentioned; non-explosiveness, a sensitive phosphorous tip, protected by the safety head, freedom from ignition in the rough handling of packages.

The safety match composition is divided between the splint and a prepared surface on the box. As long as they remain apart the match is comparatively harmless. There is in the use of this match a minimum danger of flying parts of the head, from rough handling, from mice and from ignition by being stepped upon. In order that the ignition points might be ascertained tests were made at the Underwriters' Laboratories in specially constructed electric ovens. Several brands of each type were tested giving the following data:

	Parlor.	Sulphur.	Double Dip.	Safety.
Maximum.....	195°F.	175°	261°	357°
Minimum.....	270°	175°	263°	365°

The safety match was recommended as being the only recognized and allowable one, and was so adopted by the convention.

THEATER CONSTRUCTION AND EQUIPMENT. COMMITTEE REPORT.—It was recommended that the stage and auditorium be separated by a self-supporting brick wall of the same thickness as the outer walls. This should extend 4 ft. above the roofs and should be coped. There should be no openings other than the curtain hole and two smaller doors at or below the stage level. The two minor openings should be provided with self-closing fire doors. Standard requirements for asbestos curtains were added, though a statement was made that the best curtain could not be considered a positive fire stop, and would serve merely to hold back the flames long enough to allow a hasty exit of the audience.

FIRE PUMPS. COMMITTEE REPORT.—It was reported that the past year's record of the Underwriters' Standard pumps have been satisfactory. A few recommendations were made for slight changes of mechanical details of the steam driven and rotary pumps. It was stated that the centrifugal fire pump had sufficiently developed to warrant a revision of the preliminary specifications of 1906. Such specifications were included in the report and were adopted by the convention.

At the close of the technical sessions the following officers were elected:

President, W. W. Dudley, Chicago, Ill.; Vice-President, W. A. Anderson, New York City; Secretary and Treasurer, W. H. Merrill, Jr., Chicago, Ill.; Executive Committee, H. C. Henley, St. Louis, Mo. (Chairman), Albert Blauvelt, J. E. Curtis, E. B. Creighton, H. H. Glidden, C. M. Goddard, F. E. MacKnight, H. K. Miller, H. L. Phillips, C. H Phinney, Alfred Stone, M. D. Pierce, C. A. Hexamer and T. B. Sellers.

Copies of the reports and papers presented at the meeting may be obtained by addressing the New York office of the Association at the Engineering Societies Building, 29 West 39th St.

NOTES FROM ENGINEERING SCHOOLS.

UNIVERSITY OF MICHIGAN.—The Michigan State Telephone Co. has installed, in the new engineering building, a Western Electric central telephone station and plant. While this gives service to the University buildings, it is intended also for use in the special courses in telephone engineering.

PRINCETON UNIVERSITY.—Announcement has been made of a gift of $1,200,000 for the erection, equipment and maintenance of two scientific laboratories, one for physical science and the other for geology and biology. The buildings will be started before the beginning of another college year. The donors are not announced.

STEVENS INSTITUTE OF TECHNOLOGY.—At a recent meeting of the College Entrance Examination Board, Stevens Institute was admitted to membership. Entrance examinations to this school will hereafter be given by this board, with the examinations for all colleges represented by this board. The next scheduled series will be held June 17-22 at about 150 places in this country and Europe.

UNIVERSITY OF ILLINOIS.—A leaflet issued by this institution shows in condensed form the work of the newly organized School of Railway Engineering and Administration. This school gives three courses in the College of Engineering, known as Railway Civil, Railway Electrical, and Railway Mechanical Engineering. One course is given in the College of Literature, under the Department of Economics, known as Railway Administration.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—Prof. H. E. Clifford, of the Electrical Engineering Department, will next year expand his lectures on alternating current into a graduate course, particularly intended for graduate students who are attending the Institute for the purpose of spending a fifth year or obtaining a second degree. It is intended to make the course the most complete in any American technical school.

COLUMBIA UNIVERSITY.—During the coming summer session the Department of Civil Engineering will offer two courses as briefly outlined below. The one on structures is to be given by Prof. William H. Burr, head of the department, and the other, on hydraulics, by some prominent hydraulician not yet selected.

Course in Structures (5 hours lectures): General considerations of the design of long span steel and suspension bridges; masonry arches; elastic arches; the design of concrete steel structures; surface finish of concrete structures, etc., etc.

Course in Hydraulics (5 hours lectures): Pumps and pumping engines; flow of water; gaging of water for irrigation systems; design of city pipe lines; flow in and discharge of open canals and rivers; stream gaging, etc., etc.

GENERAL ELECTRIC DRAFTING SCHOOL.—This company maintains at Schenectady a course in drafting for young men who do not desire to take a more complete technical course in some school. It is practically an apprentice system, extending over about three years.

After an entrance examination in arithmetic, he is put in the blue print department for three months. The next nine months are spent in the tracing departments. Up to the end of this first year the working hours are eight, each day.

The entire second year is spent in the factory, three months to each general department of work. A ten-hour day prevails in the shops.

At the beginning of the third year the student is admitted to the general drafting rooms for one or two years, depending on the ability of the individual. The end of the course usually finds him in designing.

During this time the student, or apprentice, is asked to study algebra, geometry, trigonometry and elementary mechanics, and to trace 50 sheets of electrical apparatus outside of working hours. Classes recite twice a week to two instructors.

The pay for the first six months is $3.41. It is increased then to $4.32 if good progress has been made. At the end of the third or fourth year the pay is $7.50 per week.

A SOUTHERN PACIFIC TRAIN WAS DERAILED by train wreckers about ten miles north of Los Angeles, Cal., on the night of May 21. One man was killed and 22 persons were injured. The only details available are contained in press dispatches, which state that the fish plates and bolts of a rail joint on a trestle were removed and the rails were spread by wires. The tender and five cars plunged over the trestle and fell some 16 ft. The engine remained on the ties.

THE WRECK OF A NEW YORK CENTRAL TRAIN, known as the "Buffalo and Cleveland Special," was caused by the derailment of a freight train on a parallel track. Before danger signals could be set by the crew of the freight, the passenger crashed into the derailed freight. One man was killed and two seriously injured.

A BLAST FURNACE EXPLODED at the Jones and Laughlin plant in Pittsburg on May 21. The accident occurred without warning. According to press dispatches the charge slipped as the furnace was about to be tapped. This slip evidently caused a heavy gas pressure in the first dust catcher, which exploded. Five men were

killed, among them E. B. Willard and J. A. West, furnace experts of the company.

THE STEAMER "NAOMI" BURNED in the middle of Lake Michigan while on the regular trip from Grand Haven to Milwaukee, May 21. Five men were burned to death, four of whom were coal passers imprisoned below decks.

AN EXPLOSION OF FORCITE in the excavation for the Pennsylvania Terminal in New York City on May 26 did considerable damage to surrounding property by falling rock, and injured 12 persons. According to the terminal authorities, the explosion was caused by the discharge of a hole that had missed fire and was set off by the discharge of another blast. With the exception of one workman, the injuries were to bystanders and to the inhabitants of nearby dwellings.

THE STEAM SHOVEL ENGINEERS' STRIKE at Panama appears to have been of short duration. On May 21 there were 38 crews of steam shovelmen at work out of the full complement of 46.

HEALTH CONDITIONS AT PANAMA were even better in April than in March. Among 5,484 white Americans connected with the Commission, there were only 4 deaths during the thirty days in April, which would give an annual death rate of 8.7 per thousand. This decrease in mortality is due principally to the falling off in the cases of pneumonia, there having been but 40 deaths from pneumonia in April as against 53 in March. Of these 40 deaths, 39 occurred among the negroes, and but 1 among the whites. There were 21 deaths from typhoid fever, 20 occurring among the negroes and 1 among the whites. The number of hospital cases during April was about three-fourth of the total during March, while the constantly sick rate is only 21 per thousand, which Colonel Gorgas, the Chief Sanitary Officer, considers as small a sick rate as could be found in a similar body of men anywhere.

THE EXPANDED METAL PATENT of 1894, issued to Golding, the original inventor, is to be taken before the U. S. Supreme Court for final adjudication. Golding began operations in 1884 and secured numerous patents on a process for making expanded metal by slitting the steel sheet and forming diamond-shaped meshes therefrom, but the metal was not a commercial success because the strands were irregular in shape, and lacked rigidity. In order to remedy these defects he conceived the idea of forming the meshes by an operation which stretched the steel, and thereby gave it greater tensile strength and stiffness. This cured all the previous defects, and gave the material a world-wide popularity.

A PERMANENT EXHIBITION OF SAFETY APpliances is to be opened in New York City in September by the American Institute of Social Service, which has taken up the work of agitation for the prevention of industrial accidents. The Institute's exhibit of safety appliances held in the Museum of Natural History last spring was successful and well attended. The new permanent exhibition is to be located in the new Thirty-ninth St. Building, where an entire floor has been rented for the purpose. The terms for rental of floor space are to be fixed at a rate low enough to cover the bare cost of conducting the exhibit. As the space is limited, manufacturers and inventors of safety appliances of approved merit should lose no time in making application for exhibition space. Arrangements for the exhibition are in charge of Dr. W. H. Tolman, Secretary of the Institute, 287 Fourth Ave., New York City. The Institute's work was discussed in our issue of Feb. 14 last.

ANOTHER "FERRIS" WHEEL has been taken down and sold for scrap. The "Great Wheel" at Earl's Court, a pleasure resort in London, which was erected in 1895, just after the success of the first Ferris Wheel at the Columbian Exposition, has just been dismantled. The wheel was 300 ft. in diameter and contained with its supporting frame over 1,100 net tons of steel.

MUNICIPAL REGULATION OF THE GAS SUPPLY of Detroit has been recommended by a special committee, which has submitted a draft of an ordinance to cover the subject. The proposed ordinance provides that all manufactured gas supplied hereafter in the city of Detroit for heating, power or illuminating purposes, shall be free from sulphureted hydrogen, and shall not contain more than 20 grains of sulphur per 100 cu. ft., nor more than 10 grains of ammonia per 100 cu. ft. These are common provisions where State or municipal regulation of the gas supply prevails. An unusual regulative feature is the provision that the gas in question

shall have a calorific value of not less than 600 B. T. U. gross per cu. ft., as determined by a standard calorimeter.

The proposed ordinance also provides that the gas pressure shall always be confined within the limits of 1½ to 4½ ins. of water pressure, except in certain high-pressure mains. The illuminating value of the gas must be at least 18 c. p., as determined by photometer tests on a

Bray Special low-pressure burner, slit union type, rated at 7 cu. ft. per hour, with the flow of gas adjusted to 5 cu. ft. per hour.

Provision is made for the office of gas analyst, to be appointed by the Mayor. The appointee must have

spent at least three years in the study of chemistry and physics in a college or university of recognized standing, and shall be skilled in the methods of gas analysis and testing.

The analyst would hold office for three years or until his successor is appointed, and would receive a salary of not over $2,000 per year. Failure to supply gas of the quality stipulated, if found on three occasions within a period of 30 days, will be punishable by a fine of $500, or the forfeiture of the franchise of the company supplying gas.

THE GEORGIAN BAY SHIP CANAL, which has been under survey by the Canadian Government for some two years past, will probably be reported upon at the next session of the Dominion Parliament. The engineer's estimates are not yet fully completed; but the Toronto "Globe" states that the total cost for a 21 ft. deep waterway from Lake Huron to tidewater at Montreal will be in the neighborhood of $105,000,000. This is substantially the same sum that the State of New York is now expending to make a waterway from Lake Erie to the Hudson River only 12 ft. deep, which will require transhipment of cargo from the lake steamer to a canal barge to be made at Buffalo. The Canadian Canal when built will enable a vessel to pass from Lake Superior through to Montreal. Nearly all the distance not in the open lake is in large and deep rivers where good speed can be made.

A DEEP WATERWAY from Chicago to the Gulf is favored by Governor Deneen, of Illinois. In a special message to the Illinois Legislature on May 10 he urged favorable action on pending bills permitting the Sanitary District of Chicago to extend its channel three miles farther. The following is an excerpt:

The United States has been balked for generations in any attempt at realizing a national waterway from the Lakes to the Gulf by the great cost of cutting through the Chicago Divide. That barrier has been removed by the work of the Sanitary District. This district has expended 53½ millions of dollars in a canal from Chicago to near Joliet, 37 miles long. That district now asks permission from the General Assembly to extend its channel three miles further. If this permission is granted, an expenditure of about six millions of dollars will be made in carrying out the project, and forty miles of deep waterway will be available for the national government whenever it shall be ready to accept the gift and show its appreciation by carrying the waterway on to the Mississippi.

In my biennial message I called attention in the following language to another phase of the benefits which will result to the State from the development of a deep waterway:

"In connection with this most prominent feature of the commission's work, the report of the commission shows many incidental advantages which will accrue to our own State from the construction of the proposed waterway. Among these is the creation of 120,000 electrical horsepower, which can be secured without in any way affecting the use of the waterway as a navigable channel. At the minimum estimate of $25 per horse-power, this electrical power would afford an annual income of $3,000,000.

THE GREAT GUNNISON TUNNEL for irrigation purposes in Colorado now lacks but 10,000 ft. of completion, according to a report received at Washington by the Reclamation Bureau. During April, 357 ft. of advance was made, bringing the total length driven to date up to 19,133 ft. The material in both headings has been exceedingly difficult to handle for several months past. At the east end a seam of rotten rock filled with mud was encountered on the first of April, and it was necessary to change the plan of operation entirely from methods employed in hard rock to those followed in heavy ground. As a result a large number of men left the work, as they were unaccustomed to this class of excavation and refused to work on it. At the west end the heading is advancing in sandstone, where the utmost caution is required to prevent a cave-in. Under the circumstances the progress made in April is considered exceptionally good. The concrete lining is still being placed rapidly, and it is expected that the tunnel will be completed in time to carry water for irrigation in 1908.

THE CHICAGO STREET RAILWAY SYSTEM is to be reconstructed and improved to meet the requirements of the city authorities, and the work will be under the direction of a Board of Supervising Engineers which has recently been appointed. Of this Board, Mr. Bion J. Arnold, consulting engineer to the city, for the traction affairs, is Chairman; Mr. Charles V. Weston has been appointed by the mayor as the member representing the city, and Mr. Harvey B. Fleming has been appointed to represent the City Ry. Co.'s interests. The Board will appoint assistant engineers and others to deal with the following sections of the work: 1. Roadbed and track; 2. Power distribution; 3. Power-house plant; 4. Cars and operation; 5. Subway system for street cars; 6. Accounting and auditing system for the street railways. The estimated cost of the work for the Chicago City Ry. Co. in the next three years, as given to the company by the Board will be $16,000,000. The cost of similar work by the Chicago Union Traction Co. on the north and west sides is estimated at $24,000,000.

COMBINED STEAM AND ELECTRIC TRACTION is to be employed for 38 miles on the Newton & Northwestern Ry. in Iowa, this stretch of line (between Kelley and Lanyon) serving as a link between a 25-mile branch to Des Moines and a 23-mile branch to Fort Dodge. Both branches are electric lines owned by the parties owning the steam railway, and form a line organized as the Fort Dodge, Des Moines & Southern Ry. The principal work on the 38-mile section is in erecting the pole line and the trolley and transmission wires; also bonding the rails. The trolley wire is 21 ft. 6 ins. above the rails, so as to be clear of brakemen on the roofs of box cars of the steam trains. Some curve and grade reduction work has been done in view of the higher speeds of the electric cars. Current is generated at 2,300 volts, and stepped up to 22,000-volt, three-phase current for transmission. The steam and electric trains will be under the control of a dispatcher at about the middle of the 38-mile combination stretch of line, and the movements of the electric cars will be regulated by telephone orders. These cars are 53 ft. 6 ins. long, with four Westinghouse motors and 36-in. steel wheels. Both express and passenger cars will be operated. Mr. J. L. Blake, of Boone, Iowa, is General Manager for both of the railways. Another case where combined steam and electric traction is used was recently noted in our columns.

A 150-TON ELECTRIC DERRICK of the stiff-leg type has been erected at the Clydebank shipbuilding works of John Brown & Co., near Glasgow, Scotland. The foundation consists of three 14-ft. steel cylinders filled with concrete; these extend 60 ft. below and 44 ft. above the level of the dock wall. They are spaced 64 ft. c. to c., and upon one of them is mounted the 76-ft. built-up steel mast. On the other two are mounted the steel stiff legs, the shoes of which are connected to each other by a box lattice girder, and to the shoe of the mast by solid-web box girders. The boom is a straight box lattice girder, having its top guyed from the head of the mast. It has two sets of hoisting tackle, of 30 tons and 150 tons capacity. The minimum radius of the boom is 27 ft.; the maximum radius is 120 ft. for 30 tons and 65 ft. for 150 tons. There are four series-wound motors of 65 brake-HP.; these operate the 30-ton hoist, the 150-ton hoist, the swinging gear, and the topping-lift of the boom. The speed of topping the boom when carrying a 150-ton load is 5 ft. per minute; the swinging speed is from one revolution in six minutes with a 150-ton load, to three minutes with a light load. The lifting speed ranges from 4 ft. per minute with 150 tons, 8 ft. with 75 tons, 20 ft. with 30 tons and 90 ft. with light loads. The crane was built by Cowans, Sheldon & Co., of Carlisle, England, and has been used in placing the boilers and machinery of the new turbine steamer "Lusitania," of the Cunard Line.

THE CRIPPLE CREEK DRAINAGE TUNNEL PROject, expected to drain and permit the exploitation of unworked territory estimated to contain $200,000,000 of gold ore, was inaugurated on May 11 by the Governor of Colorado with much ceremony and festivity which brought to the camp trainloads of prominent visitors from all parts of Colorado. The estimated cost of this undertaking is in the neighborhood of $1,000,000, which will be met by the mine owners, the railroads, the smelter operators, and citizens of the state, who have joined forces for the raising of the amount necessary. Between three and four years will be consumed in completing the project. When completed it will drain the entire Cripple Creek district to a depth of about 730 ft. below the present water level; drainage to the present level is obtained by the El Paso tunnel, which cuts the El Paso mine on Beacon Hill, on the west side of the district, about 600 ft. below the surface, and the Vindicator mine, on the east side of the camp, at a depth of 1,275 ft. The Beacon Hill section will therefore be drained to a depth of 1,330 ft. and the eastern section to about 2,000 ft. from the surface. The mouth of the new tunnel is located on the stream which gives the camp its name, at an elevation of 5,020 ft. above sea level.

The deepest shaft in the district is now about 1,500 ft.; hence, the new tunnel will render accessible from 700 to 1,200 ft. of ore bodies heretofore untouched. What this will mean in terms of dollars can best be shown as follows: The district has so far produced more than $200,000,000 in gold. During 1906 the output was nearly $17,000,000, a rate of production that has been steadily maintained for years. It is estimated that the completion of the project in hand will make possible the doubling of the present record of the district. During the estimated two years that will be required to push the tunnel 14,000 ft. to the main contact near the El Paso shaft, at which point it will begin to drain the district, ore will